DonorsChoose

DonorsChoose.org receives hundreds of thousands of project proposals each year for classroom projects in need of funding. Right now, a large number of volunteers is needed to manually screen each submission before it's approved to be posted on the DonorsChoose.org website.

Next year, DonorsChoose.org expects to receive close to 500,000 project proposals. As a result, there are three main problems they need to solve:

- How to scale current manual processes and resources to screen 500,000 projects so that they can be posted as quickly and as efficiently as possible
- How to increase the consistency of project vetting across different volunteers to improve the experience for teachers
- How to focus volunteer time on the applications that need the most assistance

The goal of the competition is to predict whether or not a DonorsChoose.org project proposal submitted by a teacher will be approved, using the text of project descriptions as well as additional metadata about the project, teacher, and school. DonorsChoose.org can then use this information to identify projects most likely to need further review before approval.

About the DonorsChoose Data Set

The `train.csv` data set provided by DonorsChoose contains the following features:

Feature	Description
`project_id`	A unique identifier for the proposed project. **Example:** `p036502`
`project_title`	Title of the project. **Examples:** • `Art Will Make You Happy!` • `First Grade Fun`
`project_grade_category`	Grade level of students for which the project is targeted. One of the following enumerated values: • `Grades PreK-2` • `Grades 3-5` • `Grades 6-8` • `Grades 9-12`
`project_subject_categories`	One or more (comma-separated) subject categories for the project from the following enumerated list of values: • `Applied Learning` • `Care & Hunger` • `Health & Sports` • `History & Civics` • `Literacy & Language` • `Math & Science` • `Music & The Arts` • `Special Needs` • `Warmth` **Examples:** • `Music & The Arts` • `Literacy & Language, Math & Science`
`school_state`	State where school is located (Two-letter U.S. postal code). **Example:** `WY`
`project_subject_subcategories`	One or more (comma-separated) subject subcategories for the project. **Examples:** • `Literacy`

Feature	Description
	• `Literature & Writing, Social Sciences`
`project_resource_summary`	An explanation of the resources needed for the project. **Example:** • `My students need hands on literacy materials to manage sensory needs!`
`project_essay_1`	First application essay*
`project_essay_2`	Second application essay*
`project_essay_3`	Third application essay*
`project_essay_4`	Fourth application essay*
`project_submitted_datetime`	Datetime when project application was submitted. **Example:** `2016-04-28 12:43:56.245`
`teacher_id`	A unique identifier for the teacher of the proposed project. **Example:** `bdf8baa8fedef6bfeec7ae4ff1c15c56`
`teacher_prefix`	Teacher's title. One of the following enumerated values: • `nan` • `Dr.` • `Mr.` • `Mrs.` • `Ms.` • `Teacher.`
`teacher_number_of_previously_posted_projects`	Number of project applications previously submitted by the same teacher. **Example:** `2`

* See the section **Notes on the Essay Data** for more details about these features.

Additionally, the `resources.csv` data set provides more data about the resources required for each project. Each line in this file represents a resource required by a project:

Feature	Description
`id`	A `project_id` value from the `train.csv` file. **Example:** `p036502`
`description`	Desciption of the resource. **Example:** `Tenor Saxophone Reeds, Box of 25`
`quantity`	Quantity of the resource required. **Example:** `3`
`price`	Price of the resource required. **Example:** `9.95`

Note: Many projects require multiple resources. The `id` value corresponds to a `project_id` in train.csv, so you use it as a key to retrieve all resources needed for a project:

The data set contains the following label (the value you will attempt to predict):

Label	Description
`project_is_approved`	A binary flag indicating whether DonorsChoose approved the project. A value of `0` indicates the project was not approved, and a value of `1` indicates the project was approved.

Notes on the Essay Data

Prior to May 17, 2016, the prompts for the essays were as follows:

- __project_essay_1:__ "Introduce us to your classroom"
- __project_essay_2:__ "Tell us more about your students"
- __project_essay_3:__ "Describe how your students will use the materials you're requesting"
- __project_essay_3:__ "Close by sharing why your project will make a difference"

Starting on May 17, 2016, the number of essays was reduced from 4 to 2, and the prompts for the first 2 essays were changed to the following:

- __project_essay_1:__ "Describe your students: What makes your students special? Specific details about their background, your neighborhood, and your school are all helpful."

your neighborhood, and your school are all helpful.

- __project_essay_2:__ "About your project: How will these materials make a difference in your students' learning and improve their school lives?"

  For all projects with project_submitted_datetime of 2016-05-17 and later, the values of project_essay_3 and project_essay_4 will be NaN.

In [1]:

```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")

import sqlite3
import pandas as pd
import numpy as np
import nltk
import string
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer

from sklearn.feature_extraction.text import CountVectorizer
from sklearn.metrics import confusion_matrix
from sklearn import metrics
from sklearn.metrics import roc_curve, auc
from nltk.stem.porter import PorterStemmer

import re
# Tutorial about Python regular expressions: https://pymotw.com/2/re/
import string
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from nltk.stem.wordnet import WordNetLemmatizer

from gensim.models import Word2Vec
from gensim.models import KeyedVectors
import pickle

from tqdm import tqdm
import os

from plotly import plotly
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
from collections import Counter
```

```
C:\Users\samar\Anaconda3\lib\site-packages\gensim\utils.py:1197: UserWarning: detected Windows; al
iasing chunkize to chunkize_serial
  warnings.warn("detected Windows; aliasing chunkize to chunkize_serial")
```

1.1 Reading Data

In [2]:

```
#project_data = pd.read_csv('train_data.csv')
project_data =
pd.read_csv('D:\\Studies\\Hadoop\\Python\\AppliedAICourse\\Notes\\17_Asg__REAL_PROBLEM_PREDICT_RAT
G_AMAZON\\ASSIGNMENT-2 Apply t-SNE\\Assignments_DonorsChoose\\train_data.csv')

#resource_data = pd.read_csv('resources.csv')
resource_data =
pd.read_csv('D:\\Studies\\Hadoop\\Python\\AppliedAICourse\\Notes\\17_Asg__REAL_PROBLEM_PREDICT_RAT
G_AMAZON\\ASSIGNMENT-2 Apply t-SNE\\Assignments_DonorsChoose\\resources.csv')
```

In [3]:

```
print("Number of data points in train data", project_data.shape)
print('-'*50)
print("The attributes of data :", project_data.columns.values)
```

```
Number of data points in train data (109248, 17)
---------------------------------------------------
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix' 'school_state'
 'project_submitted_datetime' 'project_grade_category'
 'project_subject_categories' 'project_subject_subcategories'
 'project_title' 'project_essay_1' 'project_essay_2' 'project_essay_3'
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects' 'project_is_approved']
```

In [4]:

```
project_data.head(3)
```

Out[4]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	pro
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Gra
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Gra
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	2016-08-31 12:03:56	Gra

In [5]:

```
# how to replace elements in list python: https://stackoverflow.com/a/2582163/4084039
cols = ['Date' if x=='project_submitted_datetime' else x for x in list(project_data.columns)]


#sort dataframe based on time pandas python: https://stackoverflow.com/a/49702492/4084039
project_data['Date'] = pd.to_datetime(project_data['project_submitted_datetime'])

# parameter of drop in python | https://www.ritchieng.com/pandas-inplace-parameter/
# parameter of drop in python axis | https://stackoverflow.com/questions/22149584/what-does-axis-in-pandas-mean
#
project_data.drop('project_submitted_datetime', axis=1, inplace=True)
project_data.sort_values(by=['Date'], inplace=True)


# how to reorder columns pandas python: https://stackoverflow.com/a/13148611/4084039
project_data = project_data[cols]


project_data.head(2)
```

Out[5]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_cate
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_cate
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5

In [6]:

```
print("Number of data points in train data", resource_data.shape)
print(resource_data.columns.values)
resource_data.head(2)
```

```
Number of data points in train data (1541272, 4)
['id' 'description' 'quantity' 'price']
```

Out[6]:

	id	description	quantity	price
0	p233245	LC652 - Lakeshore Double-Space Mobile Drying Rack	1	149.00
1	p069063	Bouncy Bands for Desks (Blue support pipes)	3	14.95

1.2 preprocessing of `project_subject_categories`

In [7]:

```
catogories = list(project_data['project_subject_categories'].values)
# remove special characters from list of strings python:
https://stackoverflow.com/a/47301924/4084039

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from-a-string
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-in-python
cat_list = []
for i in catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warmth", "Care & H
unger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Scienc
e"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to replace it with ''(i
.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math &
Science"=>"Math&Science"
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('&','_') # we are replacing the & value into
    cat_list.append(temp.strip())

project_data['clean_categories'] = cat_list
project_data.drop(['project_subject_categories'], axis=1, inplace=True)

from collections import Counter
my_counter = Counter()
for word in project_data['clean_categories'].values:
    my_counter.update(word.split())

cat_dict = dict(my_counter)
sorted_cat_dict = dict(sorted(cat_dict.items(), key=lambda kv: kv[1]))
```

In [8]:

```
project_data.head(2)
```

Out[8]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_cate

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_cate
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5

1.3 preprocessing of `project_subject_subcategories`

In [9]:

```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python:
https://stackoverflow.com/a/47301924/4084039

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from-a-string
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-in-python

sub_cat_list = []
for i in sub_catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warmth", "Care & H
unger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Scienc
e"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to replace it with ''(i
.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math &
Science"=>"Math&Science"
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('&','_')
    sub_cat_list.append(temp.strip())

project_data['clean_subcategories'] = sub_cat_list
project_data.drop(['project_subject_subcategories'], axis=1, inplace=True)

# count of all the words in corpus python: https://stackoverflow.com/a/22898595/4084039
my_counter = Counter()
for word in project_data['clean_subcategories'].values:
    my_counter.update(word.split())

sub_cat_dict = dict(my_counter)
sorted_sub_cat_dict = dict(sorted(sub_cat_dict.items(), key=lambda kv: kv[1]))
```

In [10]:

```
project_data.head(2)
```

Out[10]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_cate
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5

1.3 Text preprocessing

In [11]:

```
# merge two column text dataframe:
project_data["essay"] = project_data["project_essay_1"].map(str) +\
                        project_data["project_essay_2"].map(str) + \
                        project_data["project_essay_3"].map(str) + \
                        project_data["project_essay_4"].map(str)
```

In [12]:

```
project_data.head(2)
```

Out[12]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_cate
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5

1.4.2.3 Using Pretrained Models: TFIDF weighted W2V

In [13]:

```
# printing some random reviews
print(project_data['essay'].values[0])
print("="*50)
print(project_data['essay'].values[150])
print("="*50)
print(project_data['essay'].values[1000])
print("="*50)
print(project_data['essay'].values[20000])
print("="*50)
print(project_data['essay'].values[99999])
print("="*50)
```

```
I have been fortunate enough to use the Fairy Tale STEM kits in my classroom as well as the STEM j
ournals, which my students really enjoyed.  I would love to implement more of the Lakeshore STEM k
its in my classroom for the next school year as they provide excellent and engaging STEM
lessons.My students come from a variety of backgrounds, including language and socioeconomic statu
s.  Many of them don't have a lot of experience in science and engineering and these kits give me
the materials to provide these exciting opportunities for my students.Each month I try to do
several science or STEM/STEAM projects.  I would use the kits and robot to help guide my science i
nstruction in engaging and meaningful ways.  I can adapt the kits to my current language arts paci
ng guide where we already teach some of the material in the kits like tall tales (Paul Bunyan) or
Johnny Appleseed.  The following units will be taught in the next school year where I will
implement these kits: magnets, motion, sink vs. float, robots.  I often get to these units and don
't know If I am teaching the right way or using the right materials.    The kits will give me
additional ideas, strategies, and lessons to prepare my students in science.It is challenging to d
evelop high quality science activities.  These kits give me the materials I need to provide my
students with science activities that will go along with the curriculum in my classroom.  Although
I have some things (like magnets) in my classroom, I don't know how to use them effectively.  The
kits will provide me with the right amount of materials and show me how to use them in an
appropriate way.
```

==========
I teach high school English to students with learning and behavioral disabilities. My students all vary in their ability level. However, the ultimate goal is to increase all students literacy levels. This includes their reading, writing, and communication levels.I teach a really dynamic group of students. However, my students face a lot of challenges. My students all live in poverty and in a dangerous neighborhood. Despite these challenges, I have students who have the the desire to defeat these challenges. My students all have learning disabilities and currently all are performing below grade level. My students are visual learners and will benefit from a classroom that fulfills their preferred learning style.The materials I am requesting will allow my students to be prepared for the classroom with the necessary supplies. Too often I am challenged with students who come to school unprepared for class due to economic challenges. I want my students to be able to focus on learning and not how they will be able to get school supplies. The supplies will last all year. Students will be able to complete written assignments and maintain a classroom journal. The chart paper will be used to make learning more visual in class and to create posters to aid students in their learning. The students have access to a classroom printer. The toner will be used to print student work that is completed on the classroom Chromebooks.I want to try and remove all barriers for the students learning and create opportunities for learning. One of the biggest barriers is the students not having the resources to get pens, paper, and folders. My students will be able to increase their literacy skills because of this project.
==========
\"Life moves pretty fast. If you don't stop and look around once in awhile, you could miss it.\" from the movie, Ferris Bueller's Day Off. Think back...what do you remember about your grandparents? How amazing would it be to be able to flip through a book to see a day in their lives?My second graders are voracious readers! They love to read both fiction and nonfiction books. Their favorite characters include Pete the Cat, Fly Guy, Piggie and Elephant, and Mercy Watson. They also love to read about insects, space and plants. My students are hungry bookworms! My students are eager to learn and read about the world around them. My kids love to be at school and are like little sponges absorbing everything around them. Their parents work long hours and usually do not see their children. My students are usually cared for by their grandparents or a family friend. Most of my students do not have someone who speaks English at home. Thus it is difficult for my students to acquire language.Now think forward... wouldn't it mean a lot to your kids, nieces or nephews or grandchildren, to be able to see a day in your life today 30 years from now? Memories are so precious to us and being able to share these memories with future generations will be a rewarding experience. As part of our social studies curriculum, students will be learning about changes over time. Students will be studying photos to learn about how their community has changed over time. In particular, we will look at photos to study how the land, buildings, clothing, and schools have changed over time. As a culminating activity, my students will capture a slice of their history and preserve it through scrap booking. Key important events in their young lives will be documented with the date, location, and names. Students will be using photos from home and from school to create their second grade memories. Their scrap books will preserve their unique stories for future generations to enjoy.Your donation to this project will provide my second graders with an opportunity to learn about social studies in a fun and creative manner. Through their scrapbooks, children will share their story with others and have a historical document for the rest of their lives.
==========
\"A person's a person, no matter how small.\" (Dr.Seuss) I teach the smallest students with the biggest enthusiasm for learning. My students learn in many different ways using all of our senses and multiple intelligences. I use a wide range of techniques to help all my students succeed. \r\nStudents in my class come from a variety of different backgrounds which makes for wonderful sharing of experiences and cultures, including Native Americans.\r\nOur school is a caring community of successful learners which can be seen through collaborative student project based learning in and out of the classroom. Kindergarteners in my class love to work with hands-on materials and have many different opportunities to practice a skill before it is mastered. Having the social skills to work cooperatively with friends is a crucial aspect of the kindergarten curriculum.Montana is the perfect place to learn about agriculture and nutrition. My students love to role play in our pretend kitchen in the early childhood classroom. I have had several kids ask me, \"Can we try cooking with REAL food?\" I will take their idea and create \"Common Core Cooking Lessons\" where we learn important math and writing concepts while cooking delicious healthy food for snack time. My students will have a grounded appreciation for the work that went into making the food and knowledge of where the ingredients came from as well as how it's healthy for their bodies. This project would expand our learning of nutrition and agricultural cooking recipes by having us peel our own apples to make homemade applesauce, make our own bread, and mix up healthy plants from our classroom garden in the spring. We will also create our own cookbooks to be printed and shared with families. \r\nStudents will gain math and literature skills as well as a life long enjoyment for healthy cooking.nannan
==========
My classroom consists of twenty-two amazing sixth graders from different cultures and backgrounds. They are a social bunch who enjoy working in partners and working with groups. They are hard-working and eager to head to middle school next year. My job is to get them ready to make this transition and make it as smooth as possible. In order to do this, my students need to come to school every day and feel safe and ready to learn. Because they are getting ready to head to middle school, I give them lots of choice- choice on where to sit and work, the order to complete assignments, choice of projects, etc. Part of the students feeling safe is the ability for them to come into a welcoming, encouraging environment. My room is colorful and the atmosphere is casual. I want them to take ownership of the classroom because we ALL share it together. Because my time with them is limited, I want to ensure they get the most of this time and enjoy it to the best of their abilities.Currently, we have twenty-two desks of differing sizes, yet the desks are similar t

```
o the ones the students will use in middle school. We also have a kidney table with crates for sea
ting. I allow my students to choose their own spots while they are working independently or in
groups. More often than not, most of them move out of their desks and onto the crates. Believe it
or not, this has proven to be more successful than making them stay at their desks! It is because
of this that I am looking toward the “Flexible Seating” option for my classroom.\r\n The students
look forward to their work time so they can move around the room. I would like to get rid of the c
onstricting desks and move toward more “fun” seating options. I am requesting various seating so m
y students have more options to sit. Currently, I have a stool and a papasan chair I inherited fro
m the previous sixth-grade teacher as well as five milk crate seats I made, but I would like to gi
ve them more options and reduce the competition for the “good seats”. I am also requesting two rug
s as not only more seating options but to make the classroom more welcoming and appealing. In orde
r for my students to be able to write and complete work without desks, I am requesting a class set
of clipboards. Finally, due to curriculum that requires groups to work together, I am requesting t
ables that we can fold up when we are not using them to leave more room for our flexible seating o
ptions.\r\nI know that with more seating options, they will be that much more excited about coming
to school! Thank you for your support in making my classroom one students will remember
forever!nannan
==================================================
```

In [14]:

```
# https://stackoverflow.com/a/47091490/4084039
import re

def decontracted(phrase):
    # specific
    phrase = re.sub(r"won't", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)

    # general
    phrase = re.sub(r"n\'t", " not", phrase)
    phrase = re.sub(r"\'re", " are", phrase)
    phrase = re.sub(r"\'s", " is", phrase)
    phrase = re.sub(r"\'d", " would", phrase)
    phrase = re.sub(r"\'ll", " will", phrase)
    phrase = re.sub(r"\'t", " not", phrase)
    phrase = re.sub(r"\'ve", " have", phrase)
    phrase = re.sub(r"\'m", " am", phrase)
    return phrase
```

In [15]:

```
sent = decontracted(project_data['essay'].values[20000])
print(sent)
print("="*50)
```

```
\"A person is a person, no matter how small.\" (Dr.Seuss) I teach the smallest students with the b
iggest enthusiasm for learning. My students learn in many different ways using all of our senses a
nd multiple intelligences. I use a wide range of techniques to help all my students succeed. \r\nS
tudents in my class come from a variety of different backgrounds which makes for wonderful sharing
of experiences and cultures, including Native Americans.\r\nOur school is a caring community of su
ccessful learners which can be seen through collaborative student project based learning in and ou
t of the classroom. Kindergarteners in my class love to work with hands-on materials and have many
different opportunities to practice a skill before it is mastered. Having the social skills to wor
k cooperatively with friends is a crucial aspect of the kindergarten curriculum.Montana is the
perfect place to learn about agriculture and nutrition. My students love to role play in our
pretend kitchen in the early childhood classroom. I have had several kids ask me, \"Can we try coo
king with REAL food?\" I will take their idea and create \"Common Core Cooking Lessons\" where we
learn important math and writing concepts while cooking delicious healthy food for snack time. My
students will have a grounded appreciation for the work that went into making the food and knowled
ge of where the ingredients came from as well as how it is healthy for their bodies. This project
would expand our learning of nutrition and agricultural cooking recipes by having us peel our own
apples to make homemade applesauce, make our own bread, and mix up healthy plants from our classro
om garden in the spring. We will also create our own cookbooks to be printed and shared with famil
ies. \r\nStudents will gain math and literature skills as well as a life long enjoyment for health
y cooking.nannan
==================================================
```

In [16]:

```
# \r \n \t remove from string python: http://texthandler.com/info/remove-line-breaks-python/
sent = sent.replace('\\r', ' ')
sent = sent.replace('\\"', ' ')
sent = sent.replace('\\n', ' ')
```

```
print(sent)
```

```
 A person is a person, no matter how small.  (Dr.Seuss) I teach the smallest students with the big
gest enthusiasm for learning. My students learn in many different ways using all of our senses and
multiple intelligences. I use a wide range of techniques to help all my students succeed.
Students in my class come from a variety of different backgrounds which makes for wonderful
sharing of experiences and cultures, including Native Americans.  Our school is a caring community
of successful learners which can be seen through collaborative student project based learning in a
nd out of the classroom. Kindergarteners in my class love to work with hands-on materials and have
many different opportunities to practice a skill before it is mastered. Having the social skills t
o work cooperatively with friends is a crucial aspect of the kindergarten curriculum.Montana is
the perfect place to learn about agriculture and nutrition. My students love to role play in our p
retend kitchen in the early childhood classroom. I have had several kids ask me,  Can we try cooki
ng with REAL food?  I will take their idea and create  Common Core Cooking Lessons  where we learn
important math and writing concepts while cooking delicious healthy food for snack time. My
students will have a grounded appreciation for the work that went into making the food and knowled
ge of where the ingredients came from as well as how it is healthy for their bodies. This project
would expand our learning of nutrition and agricultural cooking recipes by having us peel our own
apples to make homemade applesauce, make our own bread, and mix up healthy plants from our classro
om garden in the spring. We will also create our own cookbooks to be printed and shared with famil
ies.   Students will gain math and literature skills as well as a life long enjoyment for healthy
cooking.nannan
```

In [17]:

```
#remove spacial character: https://stackoverflow.com/a/5843547/4084039
sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
print(sent)
```

```
 A person is a person no matter how small Dr Seuss I teach the smallest students with the biggest
enthusiasm for learning My students learn in many different ways using all of our senses and multi
ple intelligences I use a wide range of techniques to help all my students succeed Students in my
class come from a variety of different backgrounds which makes for wonderful sharing of
experiences and cultures including Native Americans Our school is a caring community of successful
learners which can be seen through collaborative student project based learning in and out of the
classroom Kindergarteners in my class love to work with hands on materials and have many different
opportunities to practice a skill before it is mastered Having the social skills to work
cooperatively with friends is a crucial aspect of the kindergarten curriculum Montana is the
perfect place to learn about agriculture and nutrition My students love to role play in our
pretend kitchen in the early childhood classroom I have had several kids ask me Can we try cooking
with REAL food I will take their idea and create Common Core Cooking Lessons where we learn
important math and writing concepts while cooking delicious healthy food for snack time My
students will have a grounded appreciation for the work that went into making the food and knowled
ge of where the ingredients came from as well as how it is healthy for their bodies This project w
ould expand our learning of nutrition and agricultural cooking recipes by having us peel our own a
pples to make homemade applesauce make our own bread and mix up healthy plants from our classroom
garden in the spring We will also create our own cookbooks to be printed and shared with families
Students will gain math and literature skills as well as a life long enjoyment for healthy cooking
nannan
```

In [18]:

```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "you've",
\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his',
'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them',
'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll",
'these', 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having',
'do', 'does', \
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', '
while', 'of', \
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during',
'before', 'after',\
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under'
, 'again', 'further',\
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'e
ach', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'very', \
```

```
, 'm', 'o', 're', \
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "d
esn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn',
"mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn',
"wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't"]
```

In [19]:

```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_essays = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays.append(sent.lower().strip())
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 109248/109248
[01:03<00:00, 1718.32it/s]
```

In [20]:

```
# after preprocesing
preprocessed_essays[20000]
```

Out[20]:

```
'person person no matter small dr seuss teach smallest students biggest enthusiasm learning
students learn many different ways using senses multiple intelligences use wide range techniques h
elp students succeed students class come variety different backgrounds makes wonderful sharing exp
eriences cultures including native americans school caring community successful learners seen coll
aborative student project based learning classroom kindergarteners class love work hands materials
many different opportunities practice skill mastered social skills work cooperatively friends cruc
ial aspect kindergarten curriculum montana perfect place learn agriculture nutrition students love
role play pretend kitchen early childhood classroom several kids ask try cooking real food take id
ea create common core cooking lessons learn important math writing concepts cooking delicious heal
thy food snack time students grounded appreciation work went making food knowledge ingredients cam
e well healthy bodies project would expand learning nutrition agricultural cooking recipes us peel
apples make homemade applesauce make bread mix healthy plants classroom garden spring also create
cookbooks printed shared families students gain math literature skills well life long enjoyment he
althy cooking nannan'
```

1.4 Preprocessing of `project_title`

In [21]:

```
# similarly you can preprocess the titles also
```

In [22]:

```
project_data.head(2)
```

Out[22]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_cate
						2016-	

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_cate
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	04-27 00:27:36	Grades PreK-2
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5

In [23]:

```
# printing some random essays.
print(project_data['project_title'].values[0])
print("="*50)
print(project_data['project_title'].values[150])
print("="*50)
print(project_data['project_title'].values[1000])
print("="*50)
print(project_data['project_title'].values[20000])
print("="*50)
print(project_data['project_title'].values[99999])
print("="*50)
```

```
Engineering STEAM into the Primary Classroom
==================================================
Building Blocks for Learning
==================================================
Empowering Students Through Art:Learning About Then and Now
==================================================
Health Nutritional Cooking in Kindergarten
==================================================
Turning to Flexible Seating: One Sixth-Grade Class's Journey to Freedom
==================================================
```

In [24]:

```
sent_title = decontracted(project_data['project_title'].values[20000])
print(sent_title)
print("="*50)
```

```
Health Nutritional Cooking in Kindergarten
==================================================
```

In [25]:

```
# \r \n \t remove from string python: http://texthandler.com/info/remove-line-breaks-python/
sent_title = sent_title.replace('\\r', ' ')
sent_title = sent_title.replace('\\"', ' ')
sent_title = sent_title.replace('\\n', ' ')
print(sent_title)
```

```
Health Nutritional Cooking in Kindergarten
```

In [26]:

```
#remove spacial character: https://stackoverflow.com/a/5843547/4084039
sent_title = re.sub('[^A-Za-z0-9]+', ' ', sent_title)
print(sent_title)
```

```
Health Nutritional Cooking in Kindergarten
```

In [27]:

```
# Combining all the above statemennts
from tqdm import tqdm
preprocessed_title = []
```

```
# tqdm is for printing the status bar
for sentance in tqdm(project_data['project_title'].values):
    sent_title = decontracted(sentance)
    sent_title = sent_title.replace('\\r', ' ')
    sent_title = sent_title.replace('\\"', ' ')
    sent_title = sent_title.replace('\\n', ' ')
    sent_title = re.sub('[^A-Za-z0-9]+', ' ', sent_title)
    # https://gist.github.com/sebleier/554280
    sent_title = ' '.join(e for e in sent_title.split() if e not in stopwords)
    preprocessed_title.append(sent_title.lower().strip())
```

```
100%|██████████████████████████████████████████████████████████████████████████| 109248/109248
[00:02<00:00, 41398.72it/s]
```

In [28]:

```
# after preprocesing
preprocessed_title[10]
```

Out[28]:

```
'a flexible classroom flexible minds'
```

1.5 Preparing data for models

In [29]:

```
project_data.columns
```

Out[29]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', 'project_title', 'project_essay_1',
       'project_essay_2', 'project_essay_3', 'project_essay_4',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'essay'],
      dtype='object')
```

we are going to consider

```
       - school_state : categorical data
       - clean_categories : categorical data
       - clean_subcategories : categorical data
       - project_grade_category : categorical data
       - teacher_prefix : categorical data

       - project_title : text data
       - text : text data
       - project_resource_summary: text data (optinal)

       - quantity : numerical (optinal)
       - teacher_number_of_previously_posted_projects : numerical
       - price : numerical
```

1.5.1 Vectorizing Categorical data

- https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/

In [30]:

```
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False, binary=True
)
# fit_transform(raw_documents[, y]) Learn the vocabulary dictionary and return term-document matri
```

```
x.
categories_one_hot = vectorizer.fit_transform(project_data['clean_categories'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",categories_one_hot.shape)
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNeeds',
'Health_Sports', 'Math_Science', 'Literacy_Language']
Shape of matrix after one hot encodig  (109248, 9)
```

In [31]:

```
# we use count vectorizer to convert the values into one
vectorizer = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=False, binary=
True)
sub_categories_one_hot = vectorizer.fit_transform(project_data['clean_subcategories'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",sub_categories_one_hot.shape)
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Extracurricular',
'Civics_Government', 'ForeignLanguages', 'NutritionEducation', 'Warmth', 'Care_Hunger',
'SocialSciences', 'PerformingArts', 'CharacterEducation', 'TeamSports', 'Other',
'College_CareerPrep', 'Music', 'History_Geography', 'Health_LifeScience', 'EarlyDevelopment', 'ESL
', 'Gym_Fitness', 'EnvironmentalScience', 'VisualArts', 'Health_Wellness', 'AppliedSciences',
'SpecialNeeds', 'Literature_Writing', 'Mathematics', 'Literacy']
Shape of matrix after one hot encodig  (109248, 30)
```

In [32]:

```
# you can do the similar thing with state, teacher_prefix and project_grade_category also
```

teacher_prefix : categorical data (one hot encoding)

In [33]:

```
# count of all the words in corpus python: https://stackoverflow.com/a/22898595/4084039
from collections import Counter
my_counter_teacher_prefix = Counter()
for word in project_data['teacher_prefix'].values:
# https://stackoverflow.com/questions/52736900/how-to-solve-the-attribute-error-float-object-has-n
o-attribute-split-in-pyth
    my_counter_teacher_prefix.update(str(word).split())

print(my_counter_teacher_prefix)
```

```
Counter({'Mrs.': 57269, 'Ms.': 38955, 'Mr.': 10648, 'Teacher': 2360, 'Dr.': 13, 'nan': 3})
```

In [34]:

```
tea_pfx_dict = dict(my_counter_teacher_prefix)
sorted_tea_pfx_dict = dict(sorted(tea_pfx_dict.items(), key=lambda kv: kv[1]))

print(sorted_tea_pfx_dict)
```

```
{'nan': 3, 'Dr.': 13, 'Teacher': 2360, 'Mr.': 10648, 'Ms.': 38955, 'Mrs.': 57269}
```

In [35]:

```
# we use count vectorizer to convert the values into one hot encoded features
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(vocabulary=list(sorted_tea_pfx_dict.keys()), lowercase=False, binary=
True)
#print(vectorizer.get_feature_names())
#https://stackoverflow.com/questions/52736900/how-to-solve-the-attribute-error-float-object-has-no
-attribute-split-in-pyth
vectorizer.fit(project_data['teacher_prefix'].astype(str).values)
print(vectorizer.get_feature_names())

# https://stackoverflow.com/questions/52736900/how-to-solve-the-attribute-error-float-object-has-n
```

```
o-attribute-split-in-pyth
tea_pfx_one_hot = vectorizer.transform(project_data['teacher_prefix'].astype(str).values)
print("Shape of matrix after one hot encodig ",tea_pfx_one_hot.shape)
print(tea_pfx_one_hot)
```

```
['nan', 'Dr.', 'Teacher', 'Mr.', 'Ms.', 'Mrs.']
Shape of matrix after one hot encodig  (109248, 6)
  (78, 2) 1
  (151, 2) 1
  (173, 2) 1
  (208, 2) 1
  (267, 2) 1
  (282, 2) 1
  (310, 2) 1
  (317, 2) 1
  (360, 2) 1
  (404, 2) 1
  (441, 2) 1
  (445, 2) 1
  (459, 2) 1
  (517, 2) 1
  (537, 2) 1
  (686, 2) 1
  (748, 2) 1
  (803, 2) 1
  (846, 2) 1
  (995, 2) 1
  (1129, 2) 1
  (1145, 2) 1
  (1191, 2) 1
  (1358, 2) 1
  (1382, 2) 1
  : :
  (108320, 2) 1
  (108353, 2) 1
  (108371, 2) 1
  (108443, 2) 1
  (108446, 2) 1
  (108519, 2) 1
  (108530, 2) 1
  (108617, 2) 1
  (108672, 2) 1
  (108686, 2) 1
  (108727, 2) 1
  (108738, 2) 1
  (108764, 2) 1
  (108814, 2) 1
  (108830, 2) 1
  (108870, 2) 1
  (108879, 2) 1
  (108922, 2) 1
  (108959, 2) 1
  (108966, 2) 1
  (109008, 2) 1
  (109011, 2) 1
  (109034, 2) 1
  (109165, 2) 1
  (109175, 2) 1
```

1.5.2 Vectorizing Text data

1.5.2.1 Bag of words

In [36]:

```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer = CountVectorizer(min_df=10)
text_bow = vectorizer.fit_transform(preprocessed_essays)
print("Shape of matrix after one hot encodig ",text_bow.shape)
```

```
Shape of matrix after one hot encodig  (109248, 16512)
```

In [37]:

```
print(type(text_bow))
print(text_bow)
```

```
<class 'scipy.sparse.csr.csr_matrix'>
  (0, 1032) 1
  (0, 13284) 1
  (0, 857) 1
  (0, 4880) 1
  (0, 14849) 1
  (0, 819) 1
  (0, 3744) 1
  (0, 796) 1
  (0, 6538) 1
  (0, 9789) 1
  (0, 479) 2
  (0, 11705) 1
  (0, 7047) 1
  (0, 4167) 1
  (0, 2520) 1
  (0, 11271) 1
  (0, 14149) 1
  (0, 7328) 1
  (0, 518) 1
  (0, 15712) 1
  (0, 16086) 2
  (0, 12541) 3
  (0, 14659) 1
  (0, 8323) 2
  (0, 6450) 1
  : :
  (109247, 8485) 1
  (109247, 8508) 3
  (109247, 15705) 1
  (109247, 1666) 1
  (109247, 3850) 1
  (109247, 16367) 3
  (109247, 8258) 2
  (109247, 8512) 1
  (109247, 7047) 1
  (109247, 518) 1
  (109247, 15712) 1
  (109247, 16086) 1
  (109247, 8323) 1
  (109247, 14654) 1
  (109247, 9088) 2
  (109247, 9947) 2
  (109247, 9011) 1
  (109247, 1407) 1
  (109247, 15766) 1
  (109247, 2966) 2
  (109247, 5113) 1
  (109247, 11579) 1
  (109247, 12905) 1
  (109247, 8824) 3
  (109247, 14226) 5
```

In [38]:

```
# you can vectorize the title also
# before you vectorize the title make sure you preprocess it
```

In [39]:

```
# Similarly you can vectorize for title also
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer = CountVectorizer(min_df=10)
text_til_bow = vectorizer.fit_transform(preprocessed_title)
print("Shape of matrix after one hot encodig ",text_til_bow.shape)
```

```
Shape of matrix after one hot encodig  (109248, 3329)
```

In [40]:

```
print(type(text_til_bow))
print(text_til_bow)
```

```
<class 'scipy.sparse.csr.csr_matrix'>
  (0, 555) 1
  (0, 2299) 1
  (0, 2788) 1
  (0, 975) 1
  (1, 1178) 1
  (1, 3031) 1
  (1, 2591) 1
  (2, 479) 1
  (2, 1755) 1
  (2, 1702) 1
  (2, 1929) 2
  (3, 2569) 1
  (3, 1160) 2
  (3, 1702) 1
  (4, 2983) 1
  (4, 1522) 1
  (4, 168) 1
  (4, 2965) 1
  (4, 750) 1
  (4, 1303) 1
  (5, 972) 1
  (5, 1466) 1
  (5, 355) 1
  (5, 366) 1
  (6, 1697) 1
  : :
  (109240, 1018) 1
  (109240, 2645) 1
  (109240, 592) 1
  (109240, 742) 1
  (109241, 29) 1
  (109241, 1318) 1
  (109241, 2569) 1
  (109241, 1160) 1
  (109242, 593) 1
  (109242, 1702) 1
  (109243, 2332) 1
  (109243, 1187) 1
  (109243, 1998) 1
  (109243, 2558) 1
  (109244, 2083) 1
  (109244, 2095) 1
  (109245, 628) 1
  (109245, 2890) 1
  (109245, 383) 1
  (109245, 555) 1
  (109246, 730) 1
  (109246, 1798) 1
  (109246, 2011) 1
  (109247, 2020) 1
  (109247, 1636) 1
```

1.5.2.2 TFIDF vectorizer

In [41]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)
text_tfidf = vectorizer.fit_transform(preprocessed_essays)
print("Shape of matrix after one hot encodig ",text_tfidf.shape)
```

```
Shape of matrix after one hot encodig  (109248, 16512)
```

In [42]:

```
print(text_tfidf.toarray())
```

```
[[0. 0. 0. ... 0. 0. 0.]
 [0. 0. 0. ... 0. 0. 0.]
 [0. 0. 0. ... 0. 0. 0.]
 ...
 [0. 0. 0. ... 0. 0. 0.]
 [0. 0. 0. ... 0. 0. 0.]
 [0. 0. 0. ... 0. 0. 0.]]
```

In [43]:

```
print(text_tfidf)
```

```
  (0, 6113) 0.06252088041192494
  (0, 5150) 0.04546006407913975
  (0, 15703) 0.09238844452258892
  (0, 5656) 0.08561711898446277
  (0, 14584) 0.09151754711100245
  (0, 14027) 0.254566131083031
  (0, 8301) 0.6307539620093391
  (0, 2774) 0.07224675947240862
  (0, 16150) 0.031068199268670826
  (0, 8125) 0.07319652473542511
  (0, 14226) 0.0653126780945719
  (0, 11903) 0.045394724583748464
  (0, 5134) 0.07887992318995302
  (0, 16384) 0.052637243004636125
  (0, 8824) 0.023942742720948297
  (0, 7438) 0.1392960353471213
  (0, 8377) 0.09058599537387589
  (0, 9871) 0.0966506407936319
  (0, 12905) 0.030106915572141034
  (0, 16436) 0.05208918499434651
  (0, 11579) 0.11364431864943807
  (0, 5400) 0.0660133205522028
  (0, 5113) 0.08368852546342903
  (0, 8576) 0.08409925235029256
  (0, 2966) 0.022468479739082076
  : :
  (109247, 7735) 0.09208808630894479
  (109247, 1871) 0.058907449148454236
  (109247, 15051) 0.28347394399008125
  (109247, 643) 0.1037972238366514
  (109247, 4833) 0.08646308225506377
  (109247, 3711) 0.10664745919867953
  (109247, 8019) 0.09908110748607182
  (109247, 1498) 0.07701842004102061
  (109247, 10560) 0.09617979075351803
  (109247, 13371) 0.1059574358619602
  (109247, 7445) 0.10666285699995894
  (109247, 7636) 0.0865893767109816
  (109247, 13741) 0.1210236841306005
  (109247, 5184) 0.10958023778455586
  (109247, 7514) 0.21394594948999004
  (109247, 7844) 0.2082802960593052
  (109247, 14282) 0.14709338492947802
  (109247, 3478) 0.19481980690594924
  (109247, 8621) 0.10831436530406943
  (109247, 4383) 0.11411671377852915
  (109247, 8889) 0.12358873993413061
  (109247, 16360) 0.13217478777393357
  (109247, 6418) 0.1611890976617283
  (109247, 11362) 0.19811961887497959
  (109247, 9717) 0.024297766337994412
```

1.5.2.3 Using Pretrained Models: Avg W2V

In [44]:

```
'''
# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039
def loadGloveModel(gloveFile):
    print ("Loading Glove Model")
```

```
    f = open(gloveFile,'r', encoding="utf8")
    model = {}
    for line in tqdm(f):
        splitLine = line.split()
        word = splitLine[0]
        embedding = np.array([float(val) for val in splitLine[1:]])
        model[word] = embedding
    print ("Done.",len(model)," words loaded!")
    return model
model = loadGloveModel('glove.42B.300d.txt')

# ============================
Output:

Loading Glove Model
1917495it [06:32, 4879.69it/s]
Done. 1917495  words loaded!

# ============================

words = []
for i in preproced_texts:
    words.extend(i.split(' '))

for i in preproced_titles:
    words.extend(i.split(' '))
print("all the words in the coupus", len(words))
words = set(words)
print("the unique words in the coupus", len(words))

inter_words = set(model.keys()).intersection(words)
print("The number of words that are present in both glove vectors and our coupus", \
      len(inter_words),"(",np.round(len(inter_words)/len(words)*100,3),"%)")

words_courpus = {}
words_glove = set(model.keys())
for i in words:
    if i in words_glove:
        words_courpus[i] = model[i]
print("word 2 vec length", len(words_courpus))


# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-sa
ve-and-load-variables-in-python/

import pickle
with open('glove_vectors', 'wb') as f:
    pickle.dump(words_courpus, f)


'''
```

Out[44]:

```
'\n# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039\ndef
loadGloveModel(gloveFile):\n    print ("Loading Glove Model")\n    f = open(gloveFile,\'r\',
encoding="utf8")\n    model = {}\n    for line in tqdm(f):\n        splitLine = line.split()\n
word = splitLine[0]\n        embedding = np.array([float(val) for val in splitLine[1:]])\n        m
odel[word] = embedding\n    print ("Done.",len(model)," words loaded!")\n    return model\nmodel =
loadGloveModel(\'glove.42B.300d.txt\')\n\n# ============================\nOutput:\n    \nLoading G
love Model\n1917495it [06:32, 4879.69it/s]\nDone. 1917495  words loaded!\n\n#
============================\n\nwords = []\nfor i in preproced_texts:\n    words.extend(i.split(\'
\'))\n\nfor i in preproced_titles:\n    words.extend(i.split(\' \'))\nprint("all the words in the
coupus", len(words))\nwords = set(words)\nprint("the unique words in the coupus",
len(words))\n\ninter_words = set(model.keys()).intersection(words)\nprint("The number of words tha
t are present in both glove vectors and our coupus",       len(inter_words),"
(",np.round(len(inter_words)/len(words)*100,3),"%)")\n\nwords_courpus = {}\nwords_glove =
set(model.keys())\nfor i in words:\n    if i in words_glove:\n        words_courpus[i] = model[i]\r
print("word 2 vec length", len(words_courpus))\n\n\n# stronging variables into pickle files python
: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-python/\n\nimport pic
kle\nwith open(\'glove_vectors\', \'wb\') as f:\n    pickle.dump(words_courpus, f)\n\n\n'
```

In [51]:

```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-sa
ve-and-load-variables-in-python/
```

```
# make sure you have the glove_vectors file
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

In [53]:

```
print(type(model))
print(type(vector))
```

```
<class 'dict'>
<class 'numpy.ndarray'>
```

In [54]:

```
# # average Word2Vec
# # compute average word2vec for each review.
# avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
# #for sentence in tqdm(preprocessed_essays): # for each review/sentence
#     vector = np.zeros(300) # as word vectors are of zero length
#     cnt_words =0; # num of words with a valid vector in the sentence/review
#     for word in sentence.split(): # for each word in a review/sentence
#         if word in glove_words:
#             vector += model[word]
#             cnt_words += 1
#     if cnt_words != 0:
#         vector /= cnt_words
#     avg_w2v_vectors.append(vector)
#
# print(len(avg_w2v_vectors))
# print(len(avg_w2v_vectors[0]))
#
# # stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-python/
#
# import pickle
# with open('avg_w2v_vectors', 'wb') as f:
#     pickle.dump(avg_w2v_vectors, f)
```

```
100%|██████████████████████████████████████████████████████████████████████████| 109248/109248 [00:30<00:00, 3622.01it/s]
```

```
109248
300
```

In [55]:

```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-python/
# make sure you have the glove_vectors file
with open('avg_w2v_vectors', 'rb') as f:
    avg_w2v_vectors = pickle.load(f)

print(len(avg_w2v_vectors))
print(len(avg_w2v_vectors[0]))
```

```
109248
300
```

1.5.2.3 Using Pretrained Models: TFIDF weighted W2V

In [57]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_essays)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

In [59]:

```
## TFIDF weighted Word2Vec
## compute average word2vec for each review.
#tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
#for sentence in tqdm(preprocessed_essays): # for each review/sentence
#    vector = np.zeros(300) # as word vectors are of zero length
#    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
#    for word in sentence.split(): # for each word in a review/sentence
#        if (word in glove_words) and (word in tfidf_words):
#            vec = model[word] # getting the vector for each word
#            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
#            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the
tfidf value for each word
#            vector += (vec * tf_idf) # calculating tfidf weighted w2v
#            tf_idf_weight += tf_idf
#    if tf_idf_weight != 0:
#        vector /= tf_idf_weight
#    tfidf_w2v_vectors.append(vector)
#
#print(len(tfidf_w2v_vectors))
#print(len(tfidf_w2v_vectors[0]))
#
## stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-s
ave-and-load-variables-in-python/
#
#import pickle
#with open('#', 'wb') as f:
#    pickle.dump(tfidf_w2v_vectors, f)
```

In [55]:

```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-sa
ve-and-load-variables-in-python/
# make sure you have the glove_vectors file
with open('tfidf_w2v_vectors', 'rb') as f:
    tfidf_w2v_vectors = pickle.load(f)

print(len(tfidf_w2v_vectors))
print(len(tfidf_w2v_vectors[0]))
```

```
109248
300
```

In [48]:

```
# Similarly you can vectorize for title also
```

TFIDF Vectorizer on project_title

In [60]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)
text_tfidf_title = vectorizer.fit_transform(preprocessed_title)
print("Shape of matrix after one hot encodig ",text_tfidf_title.shape)
```

```
Shape of matrix after one hot encodig  (109248, 3329)
```

Using Pretrained Models: AVG W2V on project_title

In [61]:

```
#words_title = []
#
#for i in preprocessed_title:
#    words_title.extend(i.split(' '))
```

```
#    words_title.extend(i.split(' '))
#
#print("all the words in the coupus", len(words_title))
#words_title = set(words_title)
#print("the unique words in the coupus", len(words_title))
#
#inter_words_title = set(model.keys()).intersection(words_title)
#print("The number of words that are present in both glove vectors and our coupus", \
#      len(inter_words_title),"(",np.round(len(inter_words_title)/len(words_title)*100,3),"%)")
#
#words_courpus_title = {}
#words_glove_title = set(model.keys())
#for i in words_title:
#    if i in words_glove_title:
#        words_courpus_title[i] = model[i]
#print("word 2 vec length", len(words_courpus_title))
#
#
## stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-python/
#
#import pickle
#with open('glove_vectors_title', 'wb') as f:
#    pickle.dump(words_courpus_title, f)
```

```
all the words in the coupus 473570
the unique words in the coupus 16903
The number of words that are present in both glove vectors and our coupus 14051 ( 83.127 %)
word 2 vec length 14051
```

In [62]:

```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-python/
# make sure you have the glove_vectors file
with open('glove_vectors_title', 'rb') as f:
    modelTitle = pickle.load(f)
    glove_words_title =  set(modelTitle.keys())
```

In [63]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_title = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_title): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words_title:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_title.append(vector)

print(len(avg_w2v_vectors_title))
print(len(avg_w2v_vectors_title[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 109248/109248 [00:01<00:00, 67202.59it/s]
```

```
109248
300
```

Using Pretrained Models: TFIDF weighted W2V on project_title

In [65]:

```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-python/
# make sure you have the glove_vectors file
```

```
with open('glove_vectors_title', 'rb') as f:
    model = pickle.load(f)
    glove_words_title =  set(model.keys())
```

In [66]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_title)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

In [67]:

```
# TFIDF weighted W2V
# compute average word2vec for each review.
tfidf_w2v_vectors_title = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_title): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words_title) and (word in tfidf_words):
            #vec = model[word] # getting the vector for each word
            #print(type(model))
            vec = model[word] # getting the vector for each word

            # here we are multiplying idf value(dictionary[word]) and
            # the tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_title.append(vector)

print(len(tfidf_w2v_vectors_title))
print(len(tfidf_w2v_vectors_title[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 109248/109248
[00:03<00:00, 31495.16it/s]
```

```
109248
300
```

1.5.3 Vectorizing Numerical features

In [68]:

```
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
project_data = pd.merge(project_data, price_data, on='id', how='left')
```

In [69]:

```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-
learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html
from sklearn.preprocessing import StandardScaler

# price_standardized = standardScalar.fit(project_data['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.   ... 399.   287.
73   5.5 ].
# Reshape your data either using array.reshape(-1, 1)

price_scalar = StandardScaler()
price_scalar.fit(project_data['price'].values.reshape(-1,1)) # finding the mean and standard
deviation of this data
print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")
```

```
# Now standardize the data with above maen and variance.
price_standardized = price_scalar.transform(project_data['price'].values.reshape(-1, 1))
```

```
Mean : 298.1193425966608, Standard deviation : 367.49634838483496
```

In [70]:

```
price_standardized
```

Out[70]:

```
array([[ 1.16172762],
       [-0.23153793],
       [ 0.08402983],
       ...,
       [ 0.27450792],
       [-0.0282706 ],
       [-0.79625102]])
```

1.5.4 Merging all the above features

- we need to merge all the numerical vectors i.e catogorical, text, numerical vectors

In [71]:

```
print(categories_one_hot.shape)
print(sub_categories_one_hot.shape)
print(text_bow.shape)
print(price_standardized.shape)
```

```
(109248, 9)
(109248, 30)
(109248, 16512)
(109248, 1)
```

In [72]:

```
print(tea_pfx_one_hot.shape) # teacher_prefix
print(text_til_bow.shape) # project title bow
print(text_tfidf.shape) # project_essay tfidf
print(text_tfidf_title.shape) # project_title tfidf
```

```
(109248, 6)
(109248, 3329)
(109248, 16512)
(109248, 3329)
```

In [73]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
#X = hstack((categories_one_hot, sub_categories_one_hot, text_bow, price_standardized))
X_CAT_NUM_TITLE_BOW = hstack(( categories_one_hot, sub_categories_one_hot, tea_pfx_one_hot,
price_standardized, text_bow, text_til_bow))
X_CAT_NUM_TITLE_BOW.shape
```

Out[73]:

```
(109248, 19887)
```

Assignment 3: Apply KNN

1. **[Task-1] Apply KNN(brute force version) on these feature sets**
   - Set 1: categorical, numerical features + project_title(BOW) + preprocessed_essay (BOW)

- Set 1: categorical, numerical features + project_title(BOW) + preprocessed_essay (BOW)
- Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_essay (TFIDF)
- Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_essay (AVG W2V)
- Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_essay (TFIDF W2V)

2. **Hyper paramter tuning to find best K**
   - Find the best hyper parameter which results in the maximum AUC value
   - Find the best hyper paramter using k-fold cross validation (or) simple cross validation data
   - Use gridsearch-cv or randomsearch-cv or write your own for loops to do this task
3. **Representation of results**
   - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, as shown in the figure
   - Once you find the best hyper parameter, you need to train your model-M using the best hyper-param. Now, find the AUC on test data and plot the ROC curve on both train and test using model-M.
   - Along with plotting ROC curve, you need to print the confusion matrix with predicted and original labels of test data points
4. **[Task-2]**
   - Select top 2000 features from feature Set 2 using `SelectKBest` and then apply KNN on top of these features
     -
```
from sklearn.datasets import load_digits
from sklearn.feature_selection import SelectKBest, chi2
X, y = load_digits(return_X_y=True)
X.shape
X_new = SelectKBest(chi2, k=20).fit_transform(X, y)
X_new.shape
========
output:
(1797, 64)
(1797, 20)
```
   - Repeat the steps 2 and 3 on the data matrix after feature selection
5. **Conclusion**
   - You need to summarize the results at the end of the notebook, summarize it in the table format. To print out a table please refer to this prettytable library link

Note: Data Leakage

1. There will be an issue of data-leakage if you vectorize the entire data and then split it into train/cv/test.
2. To avoid the issue of data-leakag, make sure to split your data first and then vectorize it.
3. While vectorizing your data, apply the method fit_transform() on you train data, and apply the method transform() on cv/test data.
4. For more details please go through this link.

Splitting Data

In [62]:

```
project_data.head(2)
```

Out[62]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category
						2016-	

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category
0	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	04-27 00:27:36	Grades PreK-2
1	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5

In [74]:

```
print(project_data.shape)
print(type(project_data))
```

```
(109248, 20)
<class 'pandas.core.frame.DataFrame'>
```

In [75]:

```
#taking 50K datapoint
project_data50K=project_data[:50000]
print(project_data50K.shape)
```

```
(50000, 20)
```

In [76]:

```
# makins Xi as 19 column matrix, where we create the modle and Yi as single colum matrix as a clas
s label.
y = project_data50K['project_is_approved'].values
project_data50K.drop(['project_is_approved'], axis=1, inplace=True)
print(y.shape)
project_data50K.head(1)
```

```
(50000,)
```

Out[76]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category
0	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2

In [77]:

```
X = project_data50K
print(X.shape)
```

```
(50000, 19)
```

2. K Nearest Neighbor

2.1 Splitting data into Train and cross validation(or test): Stratified Sampling

In [67]:

```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your code
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

In [78]:

```
# train test split | https://scikit-
learn.org/stable/modules/generated/sklearn.model_selection.train_test_split.html
# spliting Xq and Yq in Train(further into Train and CV) and Test matrix
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33, stratify=y)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=y_train)
```

In [79]:

```
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("="*100)
```

```
(22445, 19) (22445,)
(11055, 19) (11055,)
(16500, 19) (16500,)
====================================================================================================
```

2.2 Make Data Model Ready: encoding numerical, categorical features

In [70]:

```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your code
# make sure you featurize train and test data separatly

# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

2.3.1 Make Data Model Ready: encoding school_state categorical data</h2>

In [80]:

```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
vectorizer.fit(X_train['school_state'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_state_ohe = vectorizer.transform(X_train['school_state'].values)
X_cv_state_ohe = vectorizer.transform(X_cv['school_state'].values)
X_test_state_ohe = vectorizer.transform(X_test['school_state'].values)

print("school_state After vectorizations")
print(X_train_state_ohe.shape, y_train.shape)
print(X_cv_state_ohe.shape, y_cv.shape)
print(X_test_state_ohe.shape, y_test.shape)
```

```
print(X_test_state_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
school_state After vectorizations
(22445, 50) (22445,)
(11055, 50) (11055,)
(16500, 50) (16500,)
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi', 'ia', 'id', 'il', 'in', 'k
s', 'ky', 'la', 'ma', 'md', 'me', 'mi', 'mn', 'mo', 'ms', 'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm',
'nv', 'ny', 'oh', 'ok', 'or', 'pa', 'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va', 'vt', 'wa', 'wi', 'wv
']
====================================================================================================
```

2.3.2 Make Data Model Ready: encoding clean_categories</h2>

In [81]:

```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
vectorizer.fit(X_train['clean_categories'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_clean_ohe = vectorizer.transform(X_train['clean_categories'].values)
X_cv_clean_ohe = vectorizer.transform(X_cv['clean_categories'].values)
X_test_clean_ohe = vectorizer.transform(X_test['clean_categories'].values)

print("clean_categories After vectorizations")
print(X_train_clean_ohe.shape, y_train.shape)
print(X_cv_clean_ohe.shape, y_cv.shape)
print(X_test_clean_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
clean_categories After vectorizations
(22445, 37) (22445,)
(11055, 37) (11055,)
(16500, 37) (16500,)
['appliedlearning', 'appliedlearning health_sports', 'appliedlearning history_civics',
'appliedlearning literacy_language', 'appliedlearning math_science', 'appliedlearning music_arts',
'appliedlearning specialneeds', 'health_sports', 'health_sports appliedlearning', 'health_sports h
istory_civics', 'health_sports literacy_language', 'health_sports math_science', 'health_sports mu
sic_arts', 'health_sports specialneeds', 'history_civics', 'history_civics literacy_language', 'hi
story_civics math_science', 'history_civics music_arts', 'history_civics specialneeds',
'literacy_language', 'literacy_language appliedlearning', 'literacy_language health_sports',
'literacy_language history_civics', 'literacy_language math_science', 'literacy_language
music_arts', 'literacy_language specialneeds', 'math_science', 'math_science appliedlearning',
'math_science health_sports', 'math_science history_civics', 'math_science literacy_language',
'math_science music_arts', 'math_science specialneeds', 'music_arts', 'music_arts specialneeds', '
specialneeds', 'specialneeds music_arts']
====================================================================================================
```

2.3.3 Make Data Model Ready: encoding clean_subcategories</h2>

In [82]:

```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
vectorizer.fit(X_train['clean_subcategories'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_cleanSub_ohe = vectorizer.transform(X_train['clean_subcategories'].values)
X_cv_cleanSub_ohe = vectorizer.transform(X_cv['clean_subcategories'].values)
X_test_cleanSub_ohe = vectorizer.transform(X_test['clean_subcategories'].values)

print("clean_subcategories After vectorizations")
print(X_train_cleanSub_ohe.shape, y_train.shape)
print(X_cv_cleanSub_ohe.shape, y_cv.shape)
```

```
print(X_test_cleanSub_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
clean_subcategories After vectorizations
(22445, 151) (22445,)
(11055, 151) (11055,)
(16500, 151) (16500,)
['appliedsciences', 'appliedsciences college_careerprep', 'appliedsciences earlydevelopment',
'appliedsciences environmentalscience', 'appliedsciences esl', 'appliedsciences extracurricular',
'appliedsciences health_lifescience', 'appliedsciences health_wellness', 'appliedsciences
history_geography', 'appliedsciences literacy', 'appliedsciences literature_writing',
'appliedsciences mathematics', 'appliedsciences other', 'appliedsciences socialsciences',
'appliedsciences specialneeds', 'appliedsciences visualarts', 'charactereducation',
'charactereducation college_careerprep', 'charactereducation communityservice',
'charactereducation earlydevelopment', 'charactereducation health_wellness', 'charactereducation l
iteracy', 'charactereducation literature_writing', 'charactereducation mathematics',
'charactereducation other', 'charactereducation specialneeds', 'charactereducation visualarts', 'c
ivics_government', 'civics_government history_geography', 'civics_government literacy',
'civics_government literature_writing', 'civics_government socialsciences', 'college_careerprep',
'college_careerprep environmentalscience', 'college_careerprep health_lifescience',
'college_careerprep literacy', 'college_careerprep literature_writing', 'college_careerprep
mathematics', 'college_careerprep other', 'college_careerprep specialneeds', 'college_careerprep v
isualarts', 'communityservice', 'communityservice environmentalscience', 'earlydevelopment',
'earlydevelopment environmentalscience', 'earlydevelopment health_wellness', 'earlydevelopment lit
eracy', 'earlydevelopment literature_writing', 'earlydevelopment mathematics', 'earlydevelopment o
ther', 'earlydevelopment specialneeds', 'earlydevelopment visualarts', 'economics',
'environmentalscience', 'environmentalscience health_lifescience', 'environmentalscience
health_wellness', 'environmentalscience history_geography', 'environmentalscience literacy', 'envi
ronmentalscience literature_writing', 'environmentalscience mathematics', 'environmentalscience nu
tritioneducation', 'environmentalscience socialsciences', 'environmentalscience specialneeds', 'en
vironmentalscience visualarts', 'esl', 'esl earlydevelopment', 'esl literacy', 'esl
literature_writing', 'esl mathematics', 'esl specialneeds', 'esl visualarts', 'extracurricular', '
extracurricular literature_writing', 'extracurricular mathematics', 'financialliteracy',
'financialliteracy mathematics', 'foreignlanguages', 'foreignlanguages literacy',
'foreignlanguages literature_writing', 'gym_fitness', 'gym_fitness health_wellness', 'gym_fitness
mathematics', 'gym_fitness nutritioneducation', 'gym_fitness specialneeds', 'gym_fitness
teamsports', 'health_lifescience', 'health_lifescience health_wellness', 'health_lifescience histo
ry_geography', 'health_lifescience literacy', 'health_lifescience literature_writing',
'health_lifescience mathematics', 'health_lifescience nutritioneducation', 'health_lifescience
socialsciences', 'health_lifescience specialneeds', 'health_lifescience visualarts',
'health_wellness', 'health_wellness literacy', 'health_wellness literature_writing',
'health_wellness mathematics', 'health_wellness music', 'health_wellness nutritioneducation',
'health_wellness other', 'health_wellness specialneeds', 'health_wellness teamsports',
'health_wellness visualarts', 'history_geography', 'history_geography literacy',
'history_geography literature_writing', 'history_geography mathematics', 'history_geography
socialsciences', 'history_geography specialneeds', 'history_geography visualarts', 'literacy',
'literacy literature_writing', 'literacy mathematics', 'literacy music', 'literacy other',
'literacy parentinvolvement', 'literacy performingarts', 'literacy socialsciences', 'literacy spec
ialneeds', 'literacy visualarts', 'literature_writing', 'literature_writing mathematics',
'literature_writing music', 'literature_writing other', 'literature_writing performingarts',
'literature_writing socialsciences', 'literature_writing specialneeds', 'literature_writing
visualarts', 'mathematics', 'mathematics music', 'mathematics other', 'mathematics
socialsciences', 'mathematics specialneeds', 'mathematics visualarts', 'music', 'music
performingarts', 'music specialneeds', 'nutritioneducation', 'other', 'other specialneeds', 'paren
tinvolvement', 'performingarts', 'performingarts visualarts', 'socialsciences', 'socialsciences
visualarts', 'specialneeds', 'specialneeds visualarts', 'teamsports', 'visualarts']
====================================================================================================
```

2.3.4 Make Data Model Ready: encoding project_grade_category</h2>

In [83]:

```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
vectorizer.fit(X_train['project_grade_category'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_grade_ohe = vectorizer.transform(X_train['project_grade_category'].values)
X_cv_grade_ohe = vectorizer.transform(X_cv['project_grade_category'].values)
X_test_grade_ohe = vectorizer.transform(X_test['project_grade_category'].values)
```

```
print("project_grade_category After vectorizations")
print(X_train_grade_ohe.shape, y_train.shape)
print(X_cv_grade_ohe.shape, y_cv.shape)
print(X_test_grade_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
project_grade_category After vectorizations
(22445, 5) (22445,)
(11055, 5) (11055,)
(16500, 5) (16500,)
['12', 'grades', 'grades 12', 'grades prek', 'prek']
====================================================================================================
```

2.3.5 Make Data Model Ready: encoding teacher_prefix</h2>

In [84]:

```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
#https://stackoverflow.com/questions/52736900/how-to-solve-the-attribute-error-float-object-has-no-attribute-split-in-pyth
vectorizer.fit(X_train['teacher_prefix'].astype(str).values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_teacher_ohe = vectorizer.transform(X_train['teacher_prefix'].astype(str).values)
X_cv_teacher_ohe = vectorizer.transform(X_cv['teacher_prefix'].astype(str).values)
X_test_teacher_ohe = vectorizer.transform(X_test['teacher_prefix'].astype(str).values)

print("teacher_prefix After vectorizations")
print(X_train_teacher_ohe.shape, y_train.shape)
print(X_cv_teacher_ohe.shape, y_cv.shape)
print(X_test_teacher_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
teacher_prefix After vectorizations
(22445, 4) (22445,)
(11055, 4) (11055,)
(16500, 4) (16500,)
['mr', 'mrs', 'ms', 'teacher']
====================================================================================================
```

2.3.6 Make Data Model Ready: project_title</h2>

In [85]:

```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['project_title'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_title_bow = vectorizer.transform(X_train['project_title'].values)
X_cv_title_bow = vectorizer.transform(X_cv['project_title'].values)
X_test_title_bow = vectorizer.transform(X_test['project_title'].values)

print("project_title After vectorizations")
print(X_train_title_bow.shape, y_train.shape)
print(X_cv_title_bow.shape, y_cv.shape)
print(X_test_title_bow.shape, y_test.shape)
#print(vectorizer.get_feature_names())
print("="*100)
```

```
project_title After vectorizations
(22445, 8005) (22445,)
(11055, 8005) (11055,)
(16500, 8005) (16500,)
====================================================================================================
```

2.3.7 Make Data Model Ready: encoding essay</h2>

In [87]:

```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
vectorizer.fit(X_train['essay'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_bow = vectorizer.transform(X_train['essay'].values)
X_cv_essay_bow = vectorizer.transform(X_cv['essay'].values)
X_test_essay_bow = vectorizer.transform(X_test['essay'].values)
```

In [88]:

```
print("Essay After vectorizations")
print(X_train_essay_bow.shape, y_train.shape)
print(X_cv_essay_bow.shape, y_cv.shape)
print(X_test_essay_bow.shape, y_test.shape)
print("="*100)
```

```
Essay After vectorizations
(22445, 5000) (22445,)
(11055, 5000) (11055,)
(16500, 5000) (16500,)
====================================================================================================
```

2.3.8 Make Data Model Ready: encoding project_resource_summary</h2>

In [89]:

```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['project_resource_summary'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_prjResSum_ohe = vectorizer.transform(X_train['project_resource_summary'].values)
X_cv_prjResSum_ohe = vectorizer.transform(X_cv['project_resource_summary'].values)
X_test_prjResSum_ohe = vectorizer.transform(X_test['project_resource_summary'].values)

print("project_resource_summary After vectorizations")
print(X_train_prjResSum_ohe.shape, y_train.shape)
print(X_cv_prjResSum_ohe.shape, y_cv.shape)
print(X_test_prjResSum_ohe.shape, y_test.shape)
#print(vectorizer.get_feature_names())
print("="*100)
```

```
project_resource_summary After vectorizations
(22445, 12011) (22445,)
(11055, 12011) (11055,)
(16500, 12011) (16500,)
====================================================================================================
```

2.3.9 Make Data Model Ready: encoding numerical | quantity</h2>

In [90]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
```

```
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['quantity'].values.reshape(-1,1))

X_train_quantity_norm = normalizer.transform(X_train['quantity'].values.reshape(-1,1))
X_cv_quantity_norm = normalizer.transform(X_cv['quantity'].values.reshape(-1,1))
X_test_quantity_norm = normalizer.transform(X_test['quantity'].values.reshape(-1,1))

print("quantity After vectorizations")
print(X_train_quantity_norm.shape, y_train.shape)
print(X_cv_quantity_norm.shape, y_cv.shape)
print(X_test_quantity_norm.shape, y_test.shape)
print("="*100)
```

```
quantity After vectorizations
(22445, 1) (22445,)
(11055, 1) (11055,)
(16500, 1) (16500,)
====================================================================================================
```

2.3.10 Make Data Model Ready: encoding numerical| teacher_number_of_previously_posted_projects</h2>

In [91]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))

X_train_TprevPrj_norm =
normalizer.transform(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
X_cv_TprevPrj_norm = normalizer.transform(X_cv['teacher_number_of_previously_posted_projects'].val
ues.reshape(-1,1))
X_test_TprevPrj_norm = normalizer.transform(X_test['teacher_number_of_previously_posted_projects']
.values.reshape(-1,1))

print("teacher_number_of_previously_posted_projects After vectorizations")
print(X_train_TprevPrj_norm.shape, y_train.shape)
print(X_cv_TprevPrj_norm.shape, y_cv.shape)
print(X_test_TprevPrj_norm.shape, y_test.shape)
print("="*100)
```

```
teacher_number_of_previously_posted_projects After vectorizations
(22445, 1) (22445,)
(11055, 1) (11055,)
(16500, 1) (16500,)
====================================================================================================
```

2.3.11 Make Data Model Ready: encoding numerical | price</h2>

In [92]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['price'].values.reshape(-1,1))
```

```
X_train_price_norm = normalizer.transform(X_train['price'].values.reshape(-1,1))
X_cv_price_norm = normalizer.transform(X_cv['price'].values.reshape(-1,1))
X_test_price_norm = normalizer.transform(X_test['price'].values.reshape(-1,1))

print("Price After vectorizations")
print(X_train_price_norm.shape, y_train.shape)
print(X_cv_price_norm.shape, y_cv.shape)
print(X_test_price_norm.shape, y_test.shape)
print("="*100)
```

```
Price After vectorizations
(22445, 1) (22445,)
(11055, 1) (11055,)
(16500, 1) (16500,)
====================================================================================================
```

In [93]:

```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your code
# make sure you featurize train and test data separatly

# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

2.4 Appling KNN on different kind of featurization as mentioned in the instructions

Apply KNN on different kind of featurization as mentioned in the instructions
For Every model that you work on make sure you do the step 2 and step 3 of instructions

In [94]:

```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your code

# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

2.4.1 Applying KNN brute force on BOW, SET 1

Please write all the code with proper documentation

- Set 1: categorical, numerical features + project_title(BOW) + preprocessed_essay (BOW)

In [95]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_bow = hstack((X_train_essay_bow, X_train_title_bow, X_train_state_ohe, X_train_clean_ohe,
X_train_cleanSub_ohe, X_train_grade_ohe, X_train_teacher_ohe, X_train_prjResSum_ohe,
X_train_quantity_norm, X_train_TprevPrj_norm, X_train_price_norm)).tocsr()
X_cv_bow = hstack((X_cv_essay_bow, X_cv_title_bow, X_cv_state_ohe, X_cv_clean_ohe,
X_cv_cleanSub_ohe, X_cv_grade_ohe, X_cv_teacher_ohe, X_cv_prjResSum_ohe, X_cv_quantity_norm, X_cv_T
prevPrj_norm, X_cv_price_norm)).tocsr()
X_te_bow = hstack((X_test_essay_bow, X_test_title_bow , X_test_state_ohe, X_test_clean_ohe, X_test_
cleanSub_ohe, X_test_grade_ohe, X_test_teacher_ohe, X_test_prjResSum_ohe, X_test_quantity_norm
```

```
X_test_TprevPrj_norm, X_test_price_norm)).tocsr()

print("Final Data matrix | BOW")
print(X_tr_bow.shape, y_train.shape)
print(X_cv_bow.shape, y_cv.shape)
print(X_te_bow.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix | BOW
(22445, 25266) (22445,)
(11055, 25266) (11055,)
(16500, 25266) (16500,)
====================================================================================================
```

2.4.2 Applying KNN brute force on TFIDF, SET 2

Please write all the code with proper documentation

- Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_essay (TFIDF)

TFIDF Vectorizer on project_essay

In [96]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
Tfidf_vectorizer = TfidfVectorizer(min_df=10)

Tfidf_vectorizer.fit(X_train['essay'].values)

X_train_text_tfidf = Tfidf_vectorizer.transform(X_train['essay'].values)
X_cv_text_tfidf = Tfidf_vectorizer.transform(X_cv['essay'].values)
X_test_text_tfidf = Tfidf_vectorizer.transform(X_test['essay'].values)

##print("Shape of matrix after one hot encodig ",text_tfidf.shape)

print("Essay After vectorizations")
print(X_train_text_tfidf.shape, y_train.shape)
print(X_cv_text_tfidf.shape, y_cv.shape)
print(X_test_text_tfidf.shape, y_test.shape)
#print(Tfidf_vectorizer.get_feature_names())
print("="*100)
```

```
Essay After vectorizations
(22445, 9031) (22445,)
(11055, 9031) (11055,)
(16500, 9031) (16500,)
====================================================================================================
```

TFIDF Vectorizer on project_title

In [97]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
Tfidf_vectorizer = TfidfVectorizer(min_df=10)

Tfidf_vectorizer.fit(X_train['project_title'].values)

X_train_title_tfidf = Tfidf_vectorizer.transform(X_train['project_title'].values)
X_cv_title_tfidf = Tfidf_vectorizer.transform(X_cv['project_title'].values)
X_test_title_tfidf = Tfidf_vectorizer.transform(X_test['project_title'].values)


##print("Shape of matrix after one hot encodig ",text_tfidf.shape)

print("project_title After vectorizations")
print(X_train_title_tfidf.shape, y_train.shape)
print(X_cv_title_tfidf.shape, y_cv.shape)
```

```
print(X_test_title_tfidf.shape, y_test.shape)
#print(Tfidf_vectorizer.get_feature_names())
print("="*100)
```

```
project_title After vectorizations
(22445, 1224) (22445,)
(11055, 1224) (11055,)
(16500, 1224) (16500,)
====================================================================================================
```

In [98]:

```
print(X_train_title_tfidf)
```

```
  (0, 236) 0.6689782882871832
  (0, 228) 0.7432819450251368
  (1, 885) 1.0
  (2, 1194) 0.5003641152034093
  (2, 1093) 0.2699207471297756
  (2, 273) 0.5537002970784922
  (2, 81) 0.6084361293519661
  (3, 1203) 0.1991961454131092
  (3, 1194) 0.21901094384766123
  (3, 692) 0.17705740857527966
  (3, 83) 0.9386190793906346
  (4, 1104) 0.6273801736097554
  (4, 797) 0.3487284740506434
  (4, 794) 0.6962632901049021
  (5, 882) 0.2947877020358642
  (5, 580) 0.27858549436020597
  (5, 512) 0.7889476762629106
  (5, 42) 0.30560079211510144
  (5, 16) 0.34591914234177656
  (6, 1192) 0.4494985411499229
  (6, 546) 0.42749449448793975
  (6, 508) 0.7843465552207085
  (7, 1120) 0.4406011557333462
  (7, 702) 0.5081061500550607
  (7, 246) 0.4328467182407207
  : :
  (22438, 45) 0.6839595219697618
  (22439, 530) 0.7170651966757833
  (22439, 464) 0.6970061002002208
  (22440, 1220) 0.41731437391355425
  (22440, 1179) 0.4598923543562394
  (22440, 1116) 0.20092305631230892
  (22440, 884) 0.32913793073052056
  (22440, 882) 0.31372858213702176
  (22440, 772) 0.27640349796989894
  (22440, 659) 0.3430524969452671
  (22440, 612) 0.41609656466532025
  (22441, 1116) 0.2921685005139029
  (22441, 1111) 0.4962780531505959
  (22441, 882) 0.4562025438675905
  (22441, 580) 0.43112860656674945
  (22441, 127) 0.5237871942278314
  (22442, 325) 1.0
  (22443, 1072) 0.5384261631739009
  (22443, 776) 0.35565705064477116
  (22443, 760) 0.505913960637619
  (22443, 546) 0.2816316963033236
  (22443, 273) 0.49833721635631917
  (22444, 1111) 0.4796871210057808
  (22444, 811) 0.5315465561118681
  (22444, 539) 0.6981106822179403
```

Please write all the code with proper documentation

- Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_essay (TFIDF)

In [99]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
```

```
from scipy.sparse import hstack
X_tr_tfidf = hstack((X_train_text_tfidf, X_train_title_tfidf, X_train_state_ohe, X_train_clean_ohe
, X_train_cleanSub_ohe, X_train_grade_ohe, X_train_teacher_ohe, X_train_prjResSum_ohe,
X_train_quantity_norm, X_train_TprevPrj_norm, X_train_price_norm)).tocsr()
X_cv_tfidf = hstack((X_cv_text_tfidf, X_cv_title_tfidf, X_cv_state_ohe, X_cv_clean_ohe, X_cv_cleanS
ub_ohe, X_cv_grade_ohe, X_cv_teacher_ohe, X_cv_prjResSum_ohe, X_cv_quantity_norm, X_cv_TprevPrj_nor
m, X_cv_price_norm)).tocsr()
X_te_tfidf = hstack((X_test_text_tfidf, X_test_title_tfidf , X_test_state_ohe, X_test_clean_ohe, X_
test_cleanSub_ohe, X_test_grade_ohe, X_test_teacher_ohe, X_test_prjResSum_ohe,
X_test_quantity_norm, X_test_TprevPrj_norm, X_test_price_norm)).tocsr()

print("Final Data matrix | tfidf")
print(X_tr_tfidf.shape, y_train.shape)
print(X_cv_tfidf.shape, y_cv.shape)
print(X_te_tfidf.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix | tfidf
(22445, 22516) (22445,)
(11055, 22516) (11055,)
(16500, 22516) (16500,)
====================================================================================================
```

2.4.3 Applying KNN brute force on AVG W2V, SET 3

Please write all the code with proper documentation

- Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_essay (AVG W2V)

In [100]:

```
## average Word2Vec for Train Essay
## compute average word2vec for each review.
#X_train_essay_avg_w2v = []; # the avg-w2v for each sentence/review is stored in this list
#for sentence in tqdm(X_train['essay'].values): # for each review/sentence
#    vector = np.zeros(300) # as word vectors are of zero length
#    cnt_words =0; # num of words with a valid vector in the sentence/review
#    for word in sentence.split(): # for each word in a review/sentence
#        if word in glove_words:
#            vector += model[word]
#            cnt_words += 1
#    if cnt_words != 0:
#        vector /= cnt_words
#    X_train_essay_avg_w2v.append(vector)
#
#print(len(X_train_essay_avg_w2v))
#print(len(X_train_essay_avg_w2v[0]))
#
## stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-s
ave-and-load-variables-in-python/
#
#import pickle
#with open('#', 'wb') as f:
#    pickle.dump(X_train_essay_avg_w2v, f)
```

```
100%|████████████████████████████████████████████████████████████████████████████| 22445/22445
[00:10<00:00, 2059.82it/s]
```

```
22445
300
```

In [101]:

```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-sa
ve-and-load-variables-in-python/
# make sure you have the glove_vectors file
with open('X_train_essay_avg_w2v', 'rb') as f:
    X_train_essay_avg_w2v = pickle.load(f)
```

In [102]:

```
# average Word2Vec for CV Essay
# compute average word2vec for each review.
X_cv_essay_avg_w2v = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    X_cv_essay_avg_w2v.append(vector)

print(len(X_cv_essay_avg_w2v))
print(len(X_cv_essay_avg_w2v[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 11055/11055
[00:05<00:00, 2063.96it/s]
```

```
11055
300
```

In [103]:

```
# average Word2Vec for Test Essay
# compute average word2vec for each review.
X_test_essay_avg_w2v = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    X_test_essay_avg_w2v.append(vector)

print(len(X_test_essay_avg_w2v))
print(len(X_test_essay_avg_w2v[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 16500/16500
[00:07<00:00, 2107.45it/s]
```

```
16500
300
```

In [104]:

```
# average Word2Vec for Train Title
# compute average word2vec for each review.
X_train_title_avg_w2v = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    X_train_title_avg_w2v.append(vector)

print(len(X_train_title_avg_w2v))
print(len(X_train_title_avg_w2v[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 22445/22445
[00:00<00:00, 114230.26it/s]
```

```
22445
300
```

In [105]:

```
# average Word2Vec for CV Title
# compute average word2vec for each review.
X_cv_title_avg_w2v = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    X_cv_title_avg_w2v.append(vector)

print(len(X_cv_title_avg_w2v))
print(len(X_cv_title_avg_w2v[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 11055/11055
[00:00<00:00, 97652.68it/s]

11055
300
```

In [106]:

```
# average Word2Vec for Test Essay
# compute average word2vec for each review.
X_test_title_avg_w2v = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    X_test_title_avg_w2v.append(vector)

print(len(X_test_title_avg_w2v))
print(len(X_test_title_avg_w2v[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 16500/16500
[00:00<00:00, 110280.39it/s]

16500
300
```

Please write all the code with proper documentation

- Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_essay (AVG W2V)

In [107]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_avgW2V = hstack((X_train_essay_avg_w2v, X_train_title_avg_w2v, X_train_state_ohe,
X_train_clean_ohe, X_train_cleanSub_ohe, X_train_grade_ohe, X_train_teacher_ohe,
X_train_prjResSum_ohe, X_train_quantity_norm, X_train_TprevPrj_norm, X_train_price_norm)).tocsr()
X_cv_avgW2V = hstack((X_cv_essay_avg_w2v, X_cv_title_avg_w2v, X_cv_state_ohe, X_cv_clean_ohe, X_cv_
cleanSub_ohe, X_cv_grade_ohe, X_cv_teacher_ohe, X_cv_prjResSum_ohe, X_cv_quantity_norm, X_cv_TprevP
rj_norm, X_cv_price_norm)).tocsr()
X_te_avgW2V = hstack((X_test_essay_avg_w2v, X_test_title_avg_w2v , X_test_state_ohe, X_test_clean_o
he, X_test_cleanSub_ohe, X_test_grade_ohe, X_test_teacher_ohe, X_test_prjResSum_ohe, X_test_quantit
y_norm, X_test_TprevPrj_norm, X_test_price_norm)).tocsr()

print("Final Data matrix | Avg W2V")
```

```
print(X_tr_avgW2V.shape, y_train.shape)
print(X_cv_avgW2V.shape, y_cv.shape)
print(X_te_avgW2V.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix | Avg W2V
(22445, 12861) (22445,)
(11055, 12861) (11055,)
(16500, 12861) (16500,)
====================================================================================================
```

2.4.4 Applying KNN brute force on TFIDF W2V, SET 4

Please write all the code with proper documentation

- Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_essay (TFIDF W2V)

In [108]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
Tr_tfidf_model_essay = TfidfVectorizer()
Tr_tfidf_model_essay.fit(X_train['essay'].values)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(Tr_tfidf_model_essay.get_feature_names(), list(Tr_tfidf_model_essay.idf_)))
tr_essay_tfidf_words = set(Tr_tfidf_model_essay.get_feature_names())
```

In [109]:

```
# TFIDF weighted Word2Vec for train essay
# compute average word2vec for each review.
tr_tfidf_w2v_essay_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tr_essay_tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tr_tfidf_w2v_essay_vectors.append(vector)

print(len(tr_tfidf_w2v_essay_vectors))
print(len(tr_tfidf_w2v_essay_vectors[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 22445/22445 [01:
48<00:00, 207.61it/s]
```

```
22445
300
```

In [110]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
cv_tfidf_model_essay = TfidfVectorizer()
cv_tfidf_model_essay.fit(X_cv['essay'].values)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(cv_tfidf_model_essay.get_feature_names(), list(cv_tfidf_model_essay.idf_)))
cv_tfidf_model_essay = set(cv_tfidf_model_essay.get_feature_names())
```

In [111]:

```
# TFIDF weighted Word2Vec for cv essay
# compute average word2vec for each review.
```

```
# compute average word2vec for each review.
cv_tfidf_w2v_essay_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in cv_tfidf_model_essay):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    cv_tfidf_w2v_essay_vectors.append(vector)

print(len(cv_tfidf_w2v_essay_vectors))
print(len(cv_tfidf_w2v_essay_vectors[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 11055/11055 [00:
53<00:00, 206.37it/s]
```

```
11055
300
```

In [112]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
te_tfidf_model_essay = TfidfVectorizer()
te_tfidf_model_essay.fit(X_test['essay'].values)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(te_tfidf_model_essay.get_feature_names(), list(te_tfidf_model_essay.idf_)))
te_tfidf_model_essay = set(te_tfidf_model_essay.get_feature_names())
```

In [113]:

```
# TFIDF weighted Word2Vec for test essay
# compute average word2vec for each review.
te_tfidf_w2v_essay_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in te_tfidf_model_essay):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    te_tfidf_w2v_essay_vectors.append(vector)

print(len(te_tfidf_w2v_essay_vectors))
print(len(te_tfidf_w2v_essay_vectors[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 16500/16500 [01:
11<00:00, 231.90it/s]
```

```
16500
300
```

In [114]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
Tr_tfidf_model_title = TfidfVectorizer()
Tr_tfidf_model_title.fit(X_train['project_title'].values)
# we are converting a dictionary with word as a key, and the idf as a value
```

```
dictionary = dict(zip(Tr_tfidf_model_title.get_feature_names(), list(Tr_tfidf_model_title.idf_)))
Tr_tfidf_model_title = set(Tr_tfidf_model_title.get_feature_names())
```

In [115]:

```
# TFIDF weighted Word2Vec for train title
# compute average word2vec for each review.
tr_tfidf_w2v_title_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in Tr_tfidf_model_title):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tr_tfidf_w2v_title_vectors.append(vector)

print(len(tr_tfidf_w2v_title_vectors))
print(len(tr_tfidf_w2v_title_vectors[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 22445/22445
[00:00<00:00, 85247.07it/s]
```

```
22445
300
```

In [116]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
cv_tfidf_model_title = TfidfVectorizer()
cv_tfidf_model_title.fit(X_cv['project_title'].values)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(cv_tfidf_model_title.get_feature_names(), list(cv_tfidf_model_title.idf_)))
cv_tfidf_model_title = set(cv_tfidf_model_title.get_feature_names())
```

In [117]:

```
# TFIDF weighted Word2Vec for cv essay
# compute average word2vec for each review.
cv_tfidf_w2v_title_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in cv_tfidf_model_title):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    cv_tfidf_w2v_title_vectors.append(vector)

print(len(cv_tfidf_w2v_title_vectors))
print(len(cv_tfidf_w2v_title_vectors[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 11055/11055
[00:00<00:00, 76446.66it/s]
```

```
11055
300
```

In [118]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
te_tfidf_model_title = TfidfVectorizer()
te_tfidf_model_title.fit(X_test['project_title'].values)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(te_tfidf_model_title.get_feature_names(), list(te_tfidf_model_title.idf_)))
te_tfidf_model_title = set(te_tfidf_model_title.get_feature_names())
```

In [119]:

```
# TFIDF weighted Word2Vec for test title
# compute average word2vec for each review.
te_tfidf_w2v_title_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in te_tfidf_model_title):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    te_tfidf_w2v_title_vectors.append(vector)

print(len(te_tfidf_w2v_title_vectors))
print(len(te_tfidf_w2v_title_vectors[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 16500/16500
[00:00<00:00, 88933.74it/s]
```

```
16500
300
```

Please write all the code with proper documentation

- Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_essay (TFIDF W2V)

In [120]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_tfidf_W2V = hstack((tr_tfidf_w2v_essay_vectors, tr_tfidf_w2v_title_vectors, X_train_state_ohe
, X_train_clean_ohe, X_train_cleanSub_ohe, X_train_grade_ohe, X_train_teacher_ohe,
X_train_prjResSum_ohe, X_train_quantity_norm, X_train_TprevPrj_norm, X_train_price_norm)).tocsr()
X_cv_tfidf_W2V = hstack((cv_tfidf_w2v_essay_vectors, cv_tfidf_w2v_title_vectors, X_cv_state_ohe, X_
cv_clean_ohe, X_cv_cleanSub_ohe, X_cv_grade_ohe, X_cv_teacher_ohe, X_cv_prjResSum_ohe,
X_cv_quantity_norm, X_cv_TprevPrj_norm, X_cv_price_norm)).tocsr()
X_te_tfidf_W2V = hstack((te_tfidf_w2v_essay_vectors, te_tfidf_w2v_title_vectors , X_test_state_ohe,
X_test_clean_ohe, X_test_cleanSub_ohe, X_test_grade_ohe, X_test_teacher_ohe, X_test_prjResSum_ohe,
X_test_quantity_norm, X_test_TprevPrj_norm, X_test_price_norm)).tocsr()

print("Final Data matrix | TFIDF W2V")
print(X_tr_tfidf_W2V.shape, y_train.shape)
print(X_cv_tfidf_W2V.shape, y_cv.shape)
print(X_te_tfidf_W2V.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix | TFIDF W2V
(22445, 12861) (22445,)
(11055, 12861) (11055,)
(16500, 12861) (16500,)
====================================================================================================
```

Hyper paramter tuning to find best K

In [121]:

```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs

    y_data_pred = []
    #print(len(y_data_pred))
    #print(data.shape)
    tr_loop = data.shape[0] - data.shape[0]%1000
    #print(tr_loop)
    # consider you X_tr shape is 49041, then your tr_loop will be 49041 - 49041%1000 = 49000
    # in this for loop we will iterate until the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        # https://scikit-
learn.org/stable/modules/generated/sklearn.neighbors.KNeighborsClassifier.html
        # predict_proba(X) Return probability estimates for the test data X.

        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])
    #print(len(y_data_pred))

    return y_data_pred
```

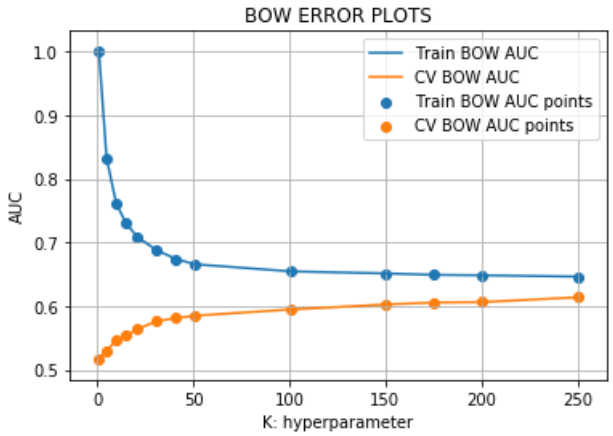
For BOW | Simple for loop

In [123]:

```
#import matplotlib.pyplot as plt
#from sklearn.neighbors import KNeighborsClassifier
#from sklearn.metrics import roc_auc_score
#"""
#y_true : array, shape = [n_samples] or [n_samples, n_classes]
#True binary labels or binary label indicators.
#
#y_score : array, shape = [n_samples] or [n_samples, n_classes]
#Target scores, can either be probability estimates of the positive class, confidence values, or n
on-thresholded measure of
#decisions (as returned by "decision_function" on some classifiers).
#For binary y_true, y_score is supposed to be the score of the class with greater label.
#
#"""
#
#train_bow_auc = []
#cv_bow_auc = []
#K = [1, 5, 10, 15, 21, 31, 41, 51, 101, 150, 175, 200, 250]
#for i in tqdm(K):
#    neigh = KNeighborsClassifier(n_neighbors=i,algorithm='brute')
#    neigh.fit(X_tr_bow, y_train)
#
#    y_train_bow_pred = batch_predict(neigh, X_tr_bow)
#    y_cv_bow_pred = batch_predict(neigh, X_cv_bow)
#
#    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the pos
itive class
#    # not the predicted outputs
#    # https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_auc_score.html
#    train_bow_auc.append(roc_auc_score(y_train,y_train_bow_pred))
#    cv_bow_auc.append(roc_auc_score(y_cv, y_cv_bow_pred))
#
####################################################################
## stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-s
ave-and-load-variables-in-python/
#
#import pickle
#with open('train_bow_auc', 'wb') as f:
#    pickle.dump(train_bow_auc, f)
#import pickle
#with open('cv_bow_auc', 'wb') as f:
#    pickle.dump(cv_bow_auc, f)
```

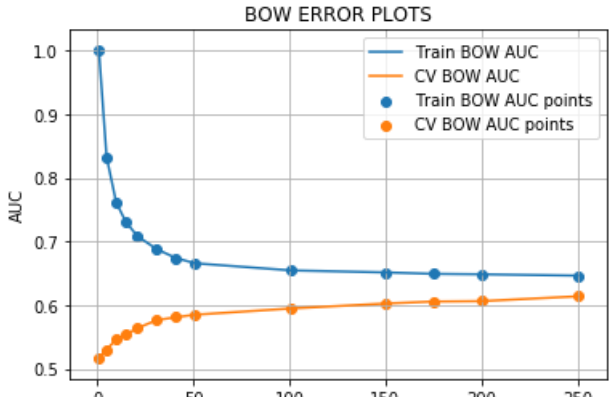
```
#########################################################################
#
#plt.plot(K, train_bow_auc, label='Train BOW AUC')
#plt.plot(K, cv_bow_auc, label='CV BOW AUC')
#
#plt.scatter(K, train_bow_auc, label='Train BOW AUC points')
#plt.scatter(K, cv_bow_auc, label='CV BOW AUC points')
#
#plt.legend()
#plt.xlabel("K: hyperparameter")
#plt.ylabel("AUC")
#plt.title("BOW ERROR PLOTS")
#plt.grid()
#plt.show()
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 13/13
[37:29<00:00, 157.64s/it]
```



In [124]:

```
import matplotlib.pyplot as plt
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-sa
ve-and-load-variables-in-python/
# make sure you have the glove_vectors file
with open('train_bow_auc', 'rb') as f:
    train_bow_auc = pickle.load(f)
with open('cv_bow_auc', 'rb') as f:
    cv_bow_auc = pickle.load(f)

plt.plot(K, train_bow_auc, label='Train BOW AUC')
plt.plot(K, cv_bow_auc, label='CV BOW AUC')

plt.scatter(K, train_bow_auc, label='Train BOW AUC points')
plt.scatter(K, cv_bow_auc, label='CV BOW AUC points')

plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("BOW ERROR PLOTS")
plt.grid()
plt.show()
```

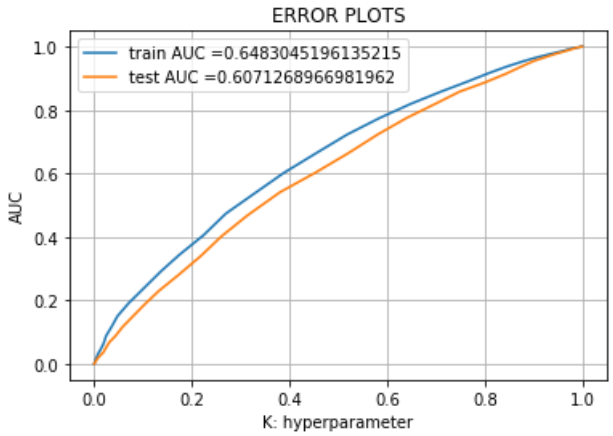


In [125]:

```
best_bow_k = 200 #(choosing 150, because, when  concanating both the two above graph ( and seeing
the y axis value)  )
# from the error plot we choose K such that, we will have maximum AUC on cv data and gap between t
he train and cv is less
```

In [126]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


neigh = KNeighborsClassifier(n_neighbors=best_bow_k,algorithm='brute')
neigh.fit(X_tr_bow, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_bow_pred = batch_predict(neigh, X_tr_bow)
y_test_bow_pred = batch_predict(neigh, X_te_bow)

train_bow_fpr, train_bow_tpr, tr_bow_thresholds = roc_curve(y_train, y_train_bow_pred)
test_bow_fpr, test_bow_tpr, te_bow_thresholds = roc_curve(y_test, y_test_bow_pred)

plt.plot(train_bow_fpr, train_bow_tpr, label="train AUC ="+str(auc(train_bow_fpr, train_bow_tpr)))
plt.plot(test_bow_fpr, test_bow_tpr, label="test AUC ="+str(auc(test_bow_fpr, test_bow_tpr)))
plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



In [127]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

    t = threshould[np.argmax(fpr*(1-tpr))]

    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high

    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

In [128]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.confusion_matrix.html
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_bow_pred, tr_bow_thresholds, train_bow_fpr,
train_bow_fpr)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_bow_pred, te_bow_thresholds, test_bow_fpr,
test_bow_fpr)))
```

```
====================================================================================================

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24965782718619006 for threshold 0.82
[[ 1731  1864]
 [ 5215 13635]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24959757392519719 for threshold 0.825
[[1268 1374]
 [4659 9199]]
```

In [138]:

```
print(type(confusion_matrix))
```

```
<class 'function'>
```

In [139]:

```
array=confusion_matrix
print(array)
```

```
<function confusion_matrix at 0x000001EC97D7C2F0>
```

In [201]:

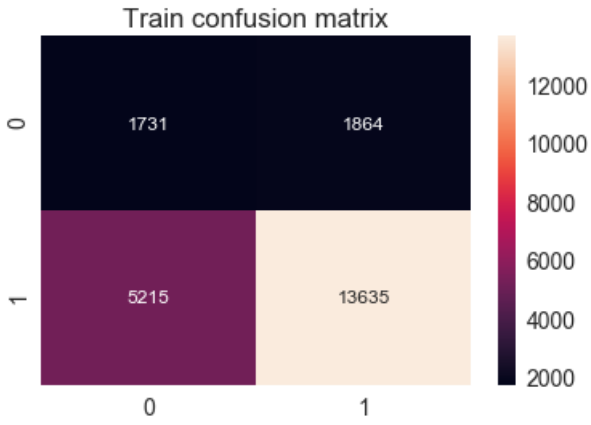
```
import seaborn as snTr
import seaborn as snTe
import pandas as pdH
import matplotlib.pyplot as plt

# https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
array=confusion_matrix(y_train, predict(y_train_bow_pred, tr_bow_thresholds, train_bow_fpr,
train_bow_fpr))
df_cm = pdH.DataFrame(array,range(2),range(2))

# https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
arrayTe=confusion_matrix(y_test, predict(y_test_bow_pred, te_bow_thresholds, test_bow_fpr,
test_bow_fpr))
df_cmTe = pdH.DataFrame(arrayTe,range(2),range(2))


# https://stackoverflow.com/questions/32723798/how-do-i-add-a-title-to-seaborn-heatmap
axTr = plt.axes()
axTr.set_title('Train confusion matrix')
snTr.set(font_scale=1.4)#for label size


# https://stackoverflow.com/questions/50947776/plot-two-seaborn-heatmap-graphs-side-by-side
fig, ax =plt.subplots(1,1)

axTe = plt.axes()
axTe.set_title('Test confusion matrix')
snTe.set(font_scale=1.4)#for label size

# https://seaborn.pydata.org/generated/seaborn.heatmap.html
snTr.heatmap(df_cm, annot=True,annot_kws={"size": 12},fmt="d",ax=axTr)# font size, format in digit
```

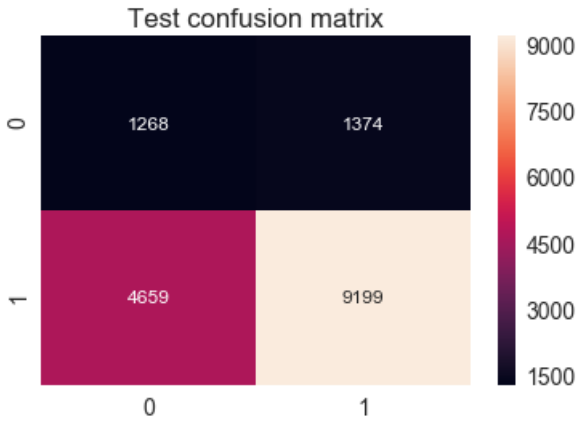
```
# https://seaborn.pydata.org/generated/seaborn.heatmap.html
snTe.heatmap(df_cmTe, annot=True,annot_kws={"size": 12},fmt="d",ax=axTe)# font size, format in
digit
```

```
the maximum value of tpr*(1-fpr) 0.24965782718619006 for threshold 0.82
the maximum value of tpr*(1-fpr) 0.24959757392519719 for threshold 0.825
```

Out[201]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1edb43c2be0>
```



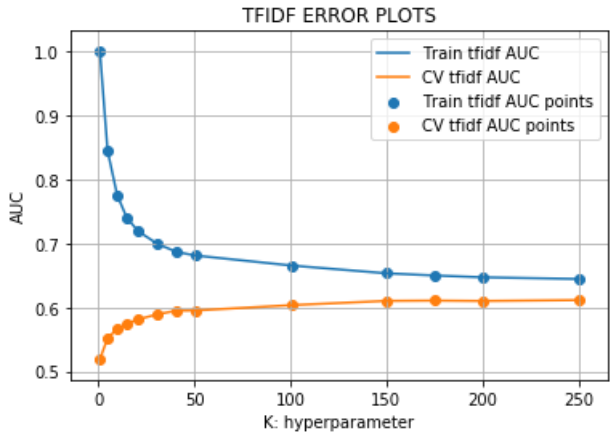


For TFIDF | Simple for loop

In [129]:

```
#import matplotlib.pyplot as plt
#from sklearn.neighbors import KNeighborsClassifier
#from sklearn.metrics import roc_auc_score
#"""
#y_true : array, shape = [n_samples] or [n_samples, n_classes]
#True binary labels or binary label indicators.
#
#y_score : array, shape = [n_samples] or [n_samples, n_classes]
#Target scores, can either be probability estimates of the positive class, confidence values, or n
on-thresholded measure of
#decisions (as returned by "decision_function" on some classifiers).
#For binary y_true, y_score is supposed to be the score of the class with greater label.
#
#"""
#
#train_tfidf_auc = []
#cv_tfidf_auc = []
#K = [1, 5, 10, 15, 21, 31, 41, 51, 101, 150, 175, 200, 250]
##for i in K:
#for i in tqdm(K):
#    neigh = KNeighborsClassifier(n_neighbors=i,algorithm='brute')
#    neigh.fit(X_tr_tfidf, y_train)
#
#    #print(X_cv_tfidf.shape)
```

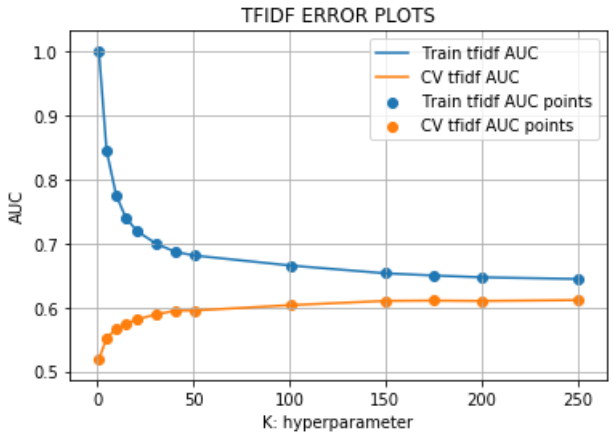
```
#
#     y_train_tfidf_pred = batch_predict(neigh, X_tr_tfidf)
#     y_cv_tfidf_pred = batch_predict(neigh, X_cv_tfidf)
#     # this will predict the probablity for data x_tr ot cv
#
#     # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the pos
itive class
#     # not the predicted outputs
#
#     # https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_auc_score.html#sklearn.metrics.roc_auc_score

#     #
#     train_tfidf_auc.append(roc_auc_score(y_train,y_train_tfidf_pred))
#     cv_tfidf_auc.append(roc_auc_score(y_cv, y_cv_tfidf_pred))
#
######################################################################
## stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-s
ave-and-load-variables-in-python/
#
#import pickle
#with open('train_tfidf_auc', 'wb') as f:
#     pickle.dump(train_tfidf_auc, f)
#
#with open('cv_tfidf_auc', 'wb') as f:
#     pickle.dump(cv_tfidf_auc, f)
######################################################################
#plt.plot(K, train_tfidf_auc, label='Train tfidf AUC')
#plt.plot(K, cv_tfidf_auc, label='CV tfidf AUC')
#
#plt.scatter(K, train_tfidf_auc, label='Train tfidf AUC points')
#plt.scatter(K, cv_tfidf_auc, label='CV tfidf AUC points')
#
#plt.legend()
#plt.xlabel("K: hyperparameter")
#plt.ylabel("AUC")
#plt.title("TFIDF ERROR PLOTS")
#plt.grid()
#plt.show()
```



In [130]:

```
import matplotlib.pyplot as plt
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-sa
ve-and-load-variables-in-python/
# make sure you have the glove_vectors file
with open('train_tfidf_auc', 'rb') as f:
    train_tfidf_auc = pickle.load(f)
with open('cv_tfidf_auc', 'rb') as f:
    cv_tfidf_auc = pickle.load(f)

plt.plot(K, train_tfidf_auc, label='Train tfidf AUC')
plt.plot(K, cv_tfidf_auc, label='CV tfidf AUC')

plt.scatter(K, train_tfidf_auc, label='Train tfidf AUC points')
plt.scatter(K, cv_tfidf_auc, label='CV tfidf AUC points')

plt.legend()
```

```
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("TFIDF ERROR PLOTS")
plt.grid()
plt.show()
```



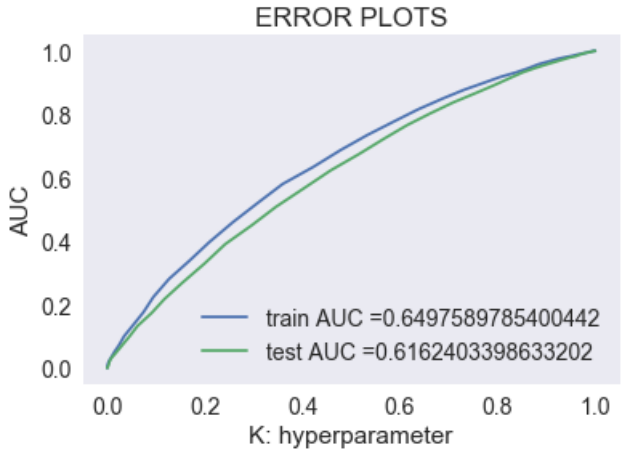
In [131]:

```
best_tfidf_k = 200
# from the error plot we choose K such that, we will have maximum AUC on cv data and gap between t
he train and cv is less
```

In [209]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


neigh = KNeighborsClassifier(n_neighbors=best_tfidf_k,algorithm='brute')
neigh.fit(X_tr_tfidf, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_tfidf_pred = batch_predict(neigh, X_tr_tfidf)
y_test_tfidf_pred = batch_predict(neigh, X_te_tfidf)

# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
# Compute Receiver operating characteristic (ROC)
# y_true : array, shape = [n_samples]
#          True binary labels. If labels are not either {-1, 1} or {0, 1}, then pos_label should b
e explicitly given.
# y_score : array, shape = [n_samples]
#          Target scores, can either be probability estimates of the positive class, confidence va
lues, or
#          non-thresholded measure of decisions (as returned by "decision_function" on some
classifiers).
#
# Returns:
# fpr : array, shape = [>2]
#          Increasing false positive rates such that element i is the false positive rate of
predictions
#          with score >= thresholds[i].
#
# tpr : array, shape = [>2]
#          Increasing true positive rates such that element i is the true positive rate of
predictions
#          with score >= thresholds[i].
#
# thresholds : array, shape = [n_thresholds]
#          Decreasing thresholds on the decision function used to compute fpr and tpr.
thresholds[0] represents
#          no instances being predicted and is arbitrarily set to max(y_score) + 1.
#
```

```
train_tfidf_fpr, train_tfidf_tpr, tr_tfidf_thresholds = roc_curve(y_train, y_train_tfidf_pred)
test_tfidf_fpr, test_tfidf_tpr, te_tfidf_thresholds = roc_curve(y_test, y_test_tfidf_pred)

plt.plot(train_tfidf_fpr, train_tfidf_tpr, label="train AUC ="+str(auc(train_tfidf_fpr, train_tfidf
_tpr)))
plt.plot(test_tfidf_fpr, test_tfidf_tpr, label="test AUC ="+str(auc(test_tfidf_fpr, test_tfidf_tpr)
))
plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



In [203]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.confusion_matrix.html
print("="*100)
from sklearn.metrics import confusion_matrix

# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.confusion_matrix.html
# Compute confusion matrix to evaluate the accuracy of a classification
# Parameters:
#     y_true : array, shape = [n_samples]     Ground truth (correct) target values.
#     y_pred : array, shape = [n_samples]     Estimated targets as returned by a classifier.
#     labels : array, shape = [n_classes], optional
#              List of labels to index the matrix. This may be used to reorder or select a subset o
f labels.
#              If none is given, those that appear at least once in y_true or y_pred are used in so
rted order.
#     sample_weight : array-like of shape = [n_samples], optional      Sample weights.
#
# Returns:
#      C : array, shape = [n_classes, n_classes]         Confusion matrix
#

print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_tfidf_pred, tr_tfidf_thresholds, train_tfidf_fpr, t
rain_tfidf_fpr)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_tfidf_pred, te_tfidf_thresholds, test_tfidf_fpr, test
_tfidf_fpr)))
```

```
====================================================================================================

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.2495109689125485 for threshold 0.846
[[ 1877  1718]
 [ 5900 12950]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24975917471280046 for threshold 0.846
[[1280 1362]
 [4513 9345]]
```

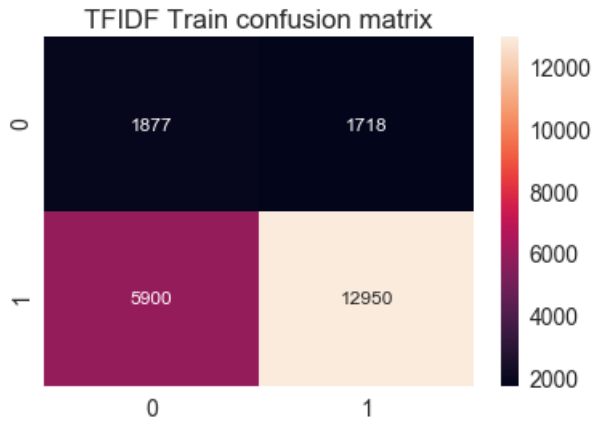
In [202]:

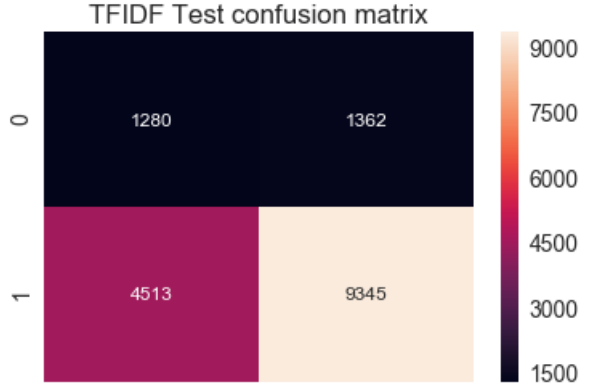
```
import seaborn as snTr
import seaborn as snTe
import pandas as pdH
import matplotlib.pyplot as plt

# https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
array=confusion_matrix(y_train, predict(y_train_tfidf_pred, tr_tfidf_thresholds, train_tfidf_fpr, t
rain_tfidf_fpr))
df_cm = pdH.DataFrame(array,range(2),range(2))

# https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
arrayTe=confusion_matrix(y_test, predict(y_test_tfidf_pred, te_tfidf_thresholds, test_tfidf_fpr, te
st_tfidf_fpr))
df_cmTe = pdH.DataFrame(arrayTe,range(2),range(2))


# https://stackoverflow.com/questions/32723798/how-do-i-add-a-title-to-seaborn-heatmap
axTr = plt.axes()
axTr.set_title('TFIDF Train confusion matrix')
snTr.set(font_scale=1.4)#for label size


# https://stackoverflow.com/questions/50947776/plot-two-seaborn-heatmap-graphs-side-by-side
fig, ax =plt.subplots(1,1)

axTe = plt.axes()
axTe.set_title('TFIDF Test confusion matrix')
snTe.set(font_scale=1.4)#for label size

# https://seaborn.pydata.org/generated/seaborn.heatmap.html
snTr.heatmap(df_cm, annot=True,annot_kws={"size": 12},fmt="d",ax=axTr)# font size, format in digit


# https://seaborn.pydata.org/generated/seaborn.heatmap.html
snTe.heatmap(df_cmTe, annot=True,annot_kws={"size": 12},fmt="d",ax=axTe)# font size, format in
digit
```

```
the maximum value of tpr*(1-fpr) 0.2495109689125485 for threshold 0.846
the maximum value of tpr*(1-fpr) 0.24975917471280046 for threshold 0.846
```

Out[202]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1edb44db1d0>
```



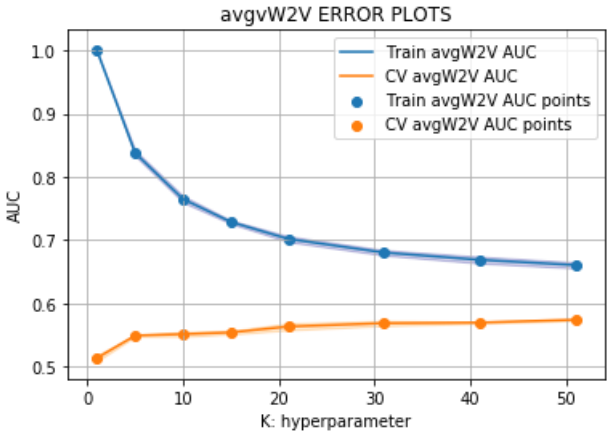


0 1

for Avg W2V | Method 2: GridSearch or randomsearch

In [113]:

```
#from sklearn.neighbors import KNeighborsClassifier
## https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
#from sklearn.model_selection import GridSearchCV
#
#neigh = KNeighborsClassifier(algorithm='brute')
#parameters = {'n_neighbors':[1, 5, 10, 15, 21, 31, 41, 51]}
#clf = GridSearchCV(neigh, parameters, cv=3, scoring='roc_auc')
#clf.fit(X_tr_avgW2V, y_train)
#
#train_avgW2V_auc= clf.cv_results_['mean_train_score']
#train_avgW2V_auc_std= clf.cv_results_['std_train_score']
#cv_avgW2V_auc = clf.cv_results_['mean_test_score']
#cv_avgW2V_auc_std= clf.cv_results_['std_test_score']
#
#plt.plot(parameters['n_neighbors'], train_avgW2V_auc, label='Train avgW2V AUC')
## this code is copied from here: https://stackoverflow.com/a/48803361/4084039
#plt.gca().fill_between(parameters['n_neighbors'],train_avgW2V_auc -
train_avgW2V_auc_std,train_avgW2V_auc + train_avgW2V_auc_std,alpha=0.2,color='darkblue')
#
#plt.plot(parameters['n_neighbors'], cv_avgW2V_auc, label='CV avgW2V AUC')
## this code is copied from here: https://stackoverflow.com/a/48803361/4084039
#plt.gca().fill_between(parameters['n_neighbors'],cv_avgW2V_auc - cv_avgW2V_auc_std,cv_avgW2V_auc
+ cv_avgW2V_auc_std,alpha=0.2,color='darkorange')
#
#plt.scatter(parameters['n_neighbors'], train_avgW2V_auc, label='Train avgW2V AUC points')
#plt.scatter(parameters['n_neighbors'], cv_avgW2V_auc, label='CV avgW2V AUC points')
#
#
#plt.legend()
#plt.xlabel("K: hyperparameter")
#plt.ylabel("AUC")
#plt.title("avgvW2V ERROR PLOTS")
#plt.grid()
#plt.show()
```



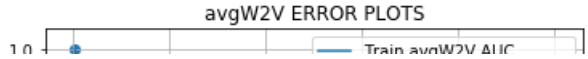
for Avg W2V | Method 1: Simple for loop

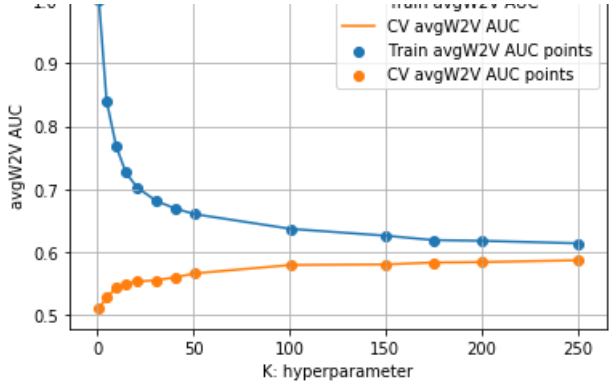
In [134]:

```
#import matplotlib.pyplot as plt
#from sklearn.neighbors import KNeighborsClassifier
#from sklearn.metrics import roc_auc_score
#"""
#y_true : array, shape = [n_samples] or [n_samples, n_classes]
#True binary labels or binary label indicators.
#
#y_score : array, shape = [n_samples] or [n_samples, n_classes]
```

```
#Target scores, can either be probability estimates of the positive class, confidence values, or n
on-thresholded measure of
#decisions (as returned by "decision_function" on some classifiers).
#For binary y_true, y_score is supposed to be the score of the class with greater label.
#
#"""
#
#train_avgW2V_auc = []
#cv_avgW2V_auc = []
#K = [1, 5, 10, 15, 21, 31, 41, 51, 101, 150, 175, 200, 250]
##for i in K:
#for i in tqdm(K):
#    # https://scikit-
learn.org/stable/modules/generated/sklearn.neighbors.KNeighborsClassifier.html
#    # Classifier implementing the k-nearest neighbors vote.
#    # fit(X, y) Fit the model using X as training data and y as target values
#    neigh = KNeighborsClassifier(n_neighbors=i,algorithm='brute')
#    neigh.fit(X_tr_avgW2V, y_train)
#
#    #print(X_cv_tfidf.shape)
#
#    y_train_avgW2V_pred = batch_predict(neigh, X_tr_avgW2V)
#    y_cv_avgW2V_pred = batch_predict(neigh, X_cv_avgW2V)
#
#    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the pos
itive class
#    # not the predicted outputs
#
#    # https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_auc_score.html#sklearn.metrics.roc_auc_score

#    # Compute Area Under the Receiver Operating Characteristic Curve (ROC AUC) from prediction sc
ores.
#    # y_true : array, shape = [n_samples] or [n_samples, n_classes] True binary labels or binary
label indicators.
#    # y_score : array, shape = [n_samples] or [n_samples, n_classes]
#    # Target scores, can either be probability estimates of the positive class, confidence values
,
#    # or non-thresholded measure of decisions (as returned by "decision_function" on some
classifiers).
#    # For binary y_true, y_score is supposed to be the score of the class with greater label.
#    #
#    # Returns:  auc : float
#
#    train_avgW2V_auc.append(roc_auc_score(y_train,y_train_avgW2V_pred))
#    cv_avgW2V_auc.append(roc_auc_score(y_cv, y_cv_avgW2V_pred))
#
#####################################################################
## stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-s
ave-and-load-variables-in-python/
#
#import pickle
#with open('train_avgW2V_auc', 'wb') as f:
#    pickle.dump(train_avgW2V_auc, f)
#
#with open('cv_avgW2V_auc', 'wb') as f:
#    pickle.dump(cv_avgW2V_auc, f)
####################################################################
#plt.plot(K, train_avgW2V_auc, label='Train avgW2V AUC')
#plt.plot(K, cv_avgW2V_auc, label='CV avgW2V AUC')
#
#plt.scatter(K, train_avgW2V_auc, label='Train avgW2V AUC points')
#plt.scatter(K, cv_avgW2V_auc, label='CV avgW2V AUC points')
#
#plt.legend()
#plt.xlabel("K: hyperparameter")
#plt.ylabel("avgW2V AUC")
#plt.title("avgW2V ERROR PLOTS")
#plt.grid()
#plt.show()
```

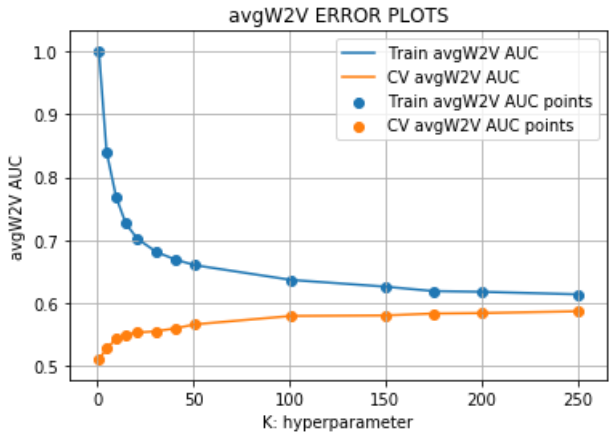
```
100%|██████████████████████████████████████████████████████████████████████████████████████████| 13/13
[2:09:06<00:00, 585.52s/it]
```





In [135]:

```
import matplotlib.pyplot as plt
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-sa
ve-and-load-variables-in-python/
# make sure you have the glove_vectors file
with open('train_avgW2V_auc', 'rb') as f:
    train_avgW2V_auc = pickle.load(f)
with open('cv_avgW2V_auc', 'rb') as f:
    cv_avgW2V_auc = pickle.load(f)

plt.plot(K, train_avgW2V_auc, label='Train avgW2V AUC')
plt.plot(K, cv_avgW2V_auc, label='CV avgW2V AUC')

plt.scatter(K, train_avgW2V_auc, label='Train avgW2V AUC points')
plt.scatter(K, cv_avgW2V_auc, label='CV avgW2V AUC points')

plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("avgW2V AUC")
plt.title("avgW2V ERROR PLOTS")
plt.grid()
plt.show()
```



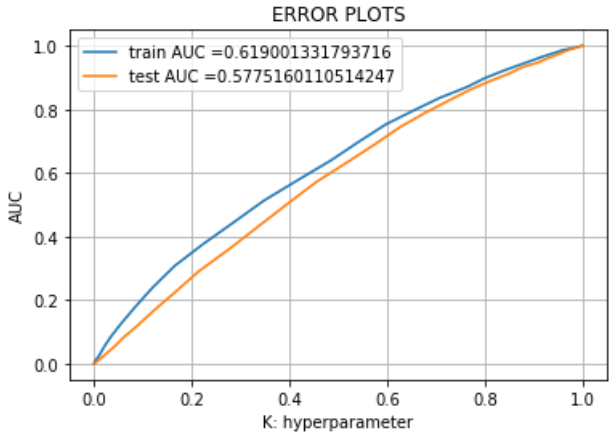
In [136]:

```
best_avgW2V_k = 175
# from the error plot we choose K such that, we will have maximum AUC on cv data and gap between t
he train and cv is less
```

In [137]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


neigh = KNeighborsClassifier(n_neighbors=best_avgW2V_k,algorithm='brute')
neigh.fit(X_tr_avgW2V, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
```

```
# not the predicted outputs

y_train_avgW2V_pred = batch_predict(neigh, X_tr_avgW2V)
y_test_avgW2V_pred = batch_predict(neigh, X_te_avgW2V)

# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
# Compute Receiver operating characteristic (ROC)
# y_true : array, shape = [n_samples]
#          True binary labels. If labels are not either {-1, 1} or {0, 1}, then pos_label should b
e explicitly given.
# y_score : array, shape = [n_samples]
#          Target scores, can either be probability estimates of the positive class, confidence va
lues, or
#          non-thresholded measure of decisions (as returned by "decision_function" on some
classifiers).
#
# Returns:
# fpr : array, shape = [>2]
#          Increasing false positive rates such that element i is the false positive rate of
predictions
#          with score >= thresholds[i].
#
# tpr : array, shape = [>2]
#          Increasing true positive rates such that element i is the true positive rate of
predictions
#          with score >= thresholds[i].
#
# thresholds : array, shape = [n_thresholds]
#          Decreasing thresholds on the decision function used to compute fpr and tpr.
thresholds[0] represents
#          no instances being predicted and is arbitrarily set to max(y_score) + 1.
#

train_avgW2V_fpr, train_avgW2V_tpr, tr_avgW2V_thresholds = roc_curve(y_train, y_train_avgW2V_pred)
test_avgW2V_fpr, test_avgW2V_tpr, te_avgW2V_thresholds = roc_curve(y_test, y_test_avgW2V_pred)

plt.plot(train_avgW2V_fpr, train_avgW2V_tpr, label="train AUC ="+str(auc(train_avgW2V_fpr, train_av
gW2V_tpr)))
plt.plot(test_avgW2V_fpr, test_avgW2V_tpr, label="test AUC ="+str(auc(test_avgW2V_fpr,
test_avgW2V_tpr)))
plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



In [162]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.confusion_matrix.html
print("="*100)
from sklearn.metrics import confusion_matrix

# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.confusion_matrix.html
# Compute confusion matrix to evaluate the accuracy of a classification
# Parameters:
#     y_true : array, shape = [n_samples]     Ground truth (correct) target values.
```

```
#     y_pred : array, shape = [n_samples]     Estimated targets as returned by a classifier.
#     labels : array, shape = [n_classes], optional
#              List of labels to index the matrix. This may be used to reorder or select a subset o
f labels.
#              If none is given, those that appear at least once in y_true or y_pred are used in so
rted order.
#     sample_weight : array-like of shape = [n_samples], optional      Sample weights.
#
# Returns:
#      C : array, shape = [n_classes, n_classes]         Confusion matrix
#

print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_avgW2V_pred, tr_avgW2V_thresholds,
train_avgW2V_fpr, train_avgW2V_fpr)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_avgW2V_pred, te_avgW2V_thresholds, test_avgW2V_fpr, t
est_avgW2V_fpr)))
```

```
====================================================================================================

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.2497947814245175 for threshold 0.857
[[ 1849  1746]
 [ 6781 12069]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24965602527390474 for threshold 0.857
[[1272 1370]
 [5073 8785]]
```

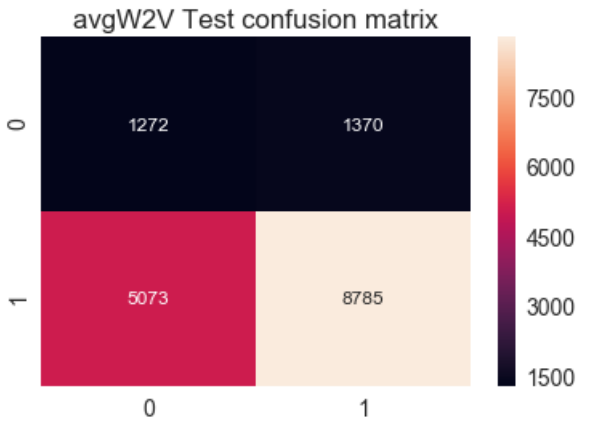
In [204]:

```
import seaborn as snTr
import seaborn as snTe
import pandas as pdH
import matplotlib.pyplot as plt

# https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
array=confusion_matrix(y_train, predict(y_train_avgW2V_pred, tr_avgW2V_thresholds,
train_avgW2V_fpr, train_avgW2V_fpr))
df_cm = pdH.DataFrame(array,range(2),range(2))

# https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
arrayTe=confusion_matrix(y_test, predict(y_test_avgW2V_pred, te_avgW2V_thresholds, test_avgW2V_fpr
, test_avgW2V_fpr))
df_cmTe = pdH.DataFrame(arrayTe,range(2),range(2))


# https://stackoverflow.com/questions/32723798/how-do-i-add-a-title-to-seaborn-heatmap
axTr = plt.axes()
axTr.set_title('avgW2V Train confusion matrix')
snTr.set(font_scale=1.4)#for label size


# https://stackoverflow.com/questions/50947776/plot-two-seaborn-heatmap-graphs-side-by-side
fig, ax =plt.subplots(1,1)

axTe = plt.axes()
axTe.set_title('avgW2V Test confusion matrix')
snTe.set(font_scale=1.4)#for label size

# https://seaborn.pydata.org/generated/seaborn.heatmap.html
snTr.heatmap(df_cm, annot=True,annot_kws={"size": 12},fmt="d",ax=axTr)# font size, format in digit


# https://seaborn.pydata.org/generated/seaborn.heatmap.html
snTe.heatmap(df_cmTe, annot=True,annot_kws={"size": 12},fmt="d",ax=axTe)# font size, format in
digit
```

```
the maximum value of tpr*(1-fpr) 0.2497947814245175 for threshold 0.857
the maximum value of tpr*(1-fpr) 0.24965602527390474 for threshold 0.857
```

Out[204]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1edb45f83c8>
```



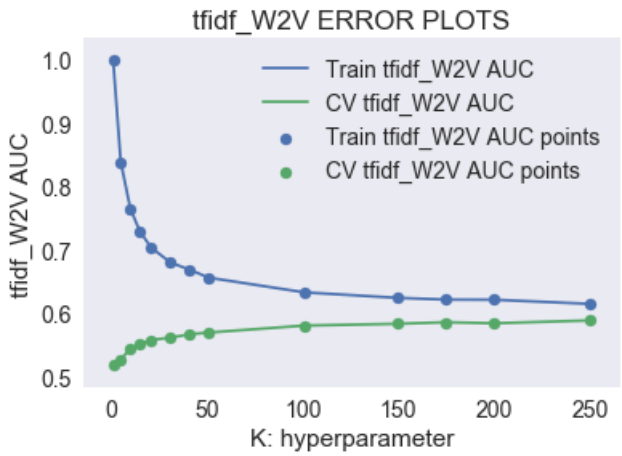
for TFIDF W2V | Simple for loop

In [163]:

```
#import matplotlib.pyplot as plt
#from sklearn.neighbors import KNeighborsClassifier
#from sklearn.metrics import roc_auc_score
#"""
#y_true : array, shape = [n_samples] or [n_samples, n_classes]
#True binary labels or binary label indicators.
#
#y_score : array, shape = [n_samples] or [n_samples, n_classes]
#Target scores, can either be probability estimates of the positive class, confidence values, or n
on-thresholded measure of
#decisions (as returned by "decision_function" on some classifiers).
#For binary y_true, y_score is supposed to be the score of the class with greater label.
#
#"""
#
#train_tfidf_W2V_auc = []
#cv_tfidf_W2V_auc = []
#K = [1, 5, 10, 15, 21, 31, 41, 51, 101, 150, 175, 200, 250]
##for i in K:
#for i in tqdm(K):
#    # https://scikit-
learn.org/stable/modules/generated/sklearn.neighbors.KNeighborsClassifier.html
#    # Classifier implementing the k-nearest neighbors vote.
#    # fit(X, y) Fit the model using X as training data and y as target values
#    neigh = KNeighborsClassifier(n_neighbors=i,algorithm='brute')
#    neigh.fit(X_tr_tfidf_W2V, y_train)
#
#    #print(X_cv_tfidf.shape)
#
#    y_train_tfidf_W2V_pred = batch_predict(neigh, X_tr_tfidf_W2V)
#    y_cv_tfidf_W2V_pred = batch_predict(neigh, X_cv_tfidf_W2V)
#
#    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the pos
itive class
```

```
#    # not the predicted outputs
#
#    # https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_auc_score.html#sklearn.metrics.roc_auc_score

#    # Compute Area Under the Receiver Operating Characteristic Curve (ROC AUC) from prediction sc
ores.
#    # y_true : array, shape = [n_samples] or [n_samples, n_classes] True binary labels or binary
label indicators.
#    # y_score : array, shape = [n_samples] or [n_samples, n_classes]
#    # Target scores, can either be probability estimates of the positive class, confidence values
,
#    # or non-thresholded measure of decisions (as returned by "decision_function" on some
classifiers).
#    # For binary y_true, y_score is supposed to be the score of the class with greater label.
#    #
#    # Returns:  auc : float
#
#    train_tfidf_W2V_auc.append(roc_auc_score(y_train,y_train_tfidf_W2V_pred))
#    cv_tfidf_W2V_auc.append(roc_auc_score(y_cv, y_cv_tfidf_W2V_pred))
#
#####################################################################
## stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-s
ave-and-load-variables-in-python/
#
#import pickle
#with open('train_tfidf_W2V_auc', 'wb') as f:
#    pickle.dump(train_tfidf_W2V_auc, f)
#
#with open('cv_tfidf_W2V_auc', 'wb') as f:
#    pickle.dump(cv_tfidf_W2V_auc, f)
#####################################################################
#plt.plot(K, train_tfidf_W2V_auc, label='Train tfidf_W2V AUC')
#plt.plot(K, cv_tfidf_W2V_auc, label='CV tfidf_W2V AUC')
#
#plt.scatter(K, train_tfidf_W2V_auc, label='Train tfidf_W2V AUC points')
#plt.scatter(K, cv_tfidf_W2V_auc, label='CV tfidf_W2V AUC points')
#
#plt.legend()
#plt.xlabel("K: hyperparameter")
#plt.ylabel("tfidf_W2V AUC")
#plt.title("tfidf_W2V ERROR PLOTS")
#plt.grid()
#plt.show()
```

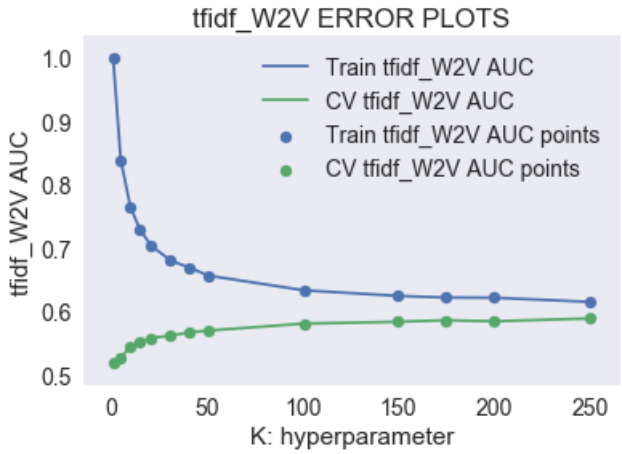
```
100%|██████████████████████████████████████████████████████████████████████████████████████████| 13/13
[1:53:53<00:00, 530.07s/it]
```



In [164]:

```
import matplotlib.pyplot as plt
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-sa
ve-and-load-variables-in-python/
# make sure you have the glove_vectors file
with open('train_tfidf_W2V_auc', 'rb') as f:
    train_tfidf_W2V_auc = pickle.load(f)
with open('cv_tfidf_W2V_auc', 'rb') as f:
```

```
    cv_tfidf_W2V_auc = pickle.load(f)

plt.plot(K, train_tfidf_W2V_auc, label='Train tfidf_W2V AUC')
plt.plot(K, cv_tfidf_W2V_auc, label='CV tfidf_W2V AUC')

plt.scatter(K, train_tfidf_W2V_auc, label='Train tfidf_W2V AUC points')
plt.scatter(K, cv_tfidf_W2V_auc, label='CV tfidf_W2V AUC points')

plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("tfidf_W2V AUC")
plt.title("tfidf_W2V ERROR PLOTS")
plt.grid()
plt.show()
```



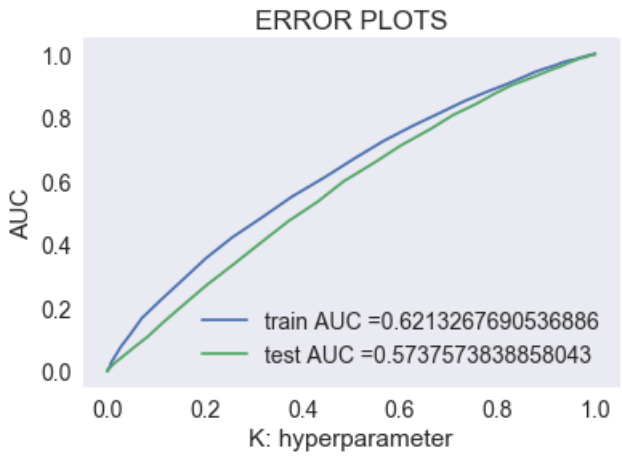
In [165]:

```
best_tfidfW2V_k = 175
# from the error plot we choose K such that, we will have maximum AUC on cv data and gap between t
he train and cv is less
```

In [166]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


neigh = KNeighborsClassifier(n_neighbors=best_tfidfW2V_k,algorithm='brute')
neigh.fit(X_tr_tfidf_W2V, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_tfidf_W2V_pred = batch_predict(neigh, X_tr_tfidf_W2V)
y_test_tfidf_W2V_pred = batch_predict(neigh, X_te_tfidf_W2V)

# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
# Compute Receiver operating characteristic (ROC)
# y_true : array, shape = [n_samples]
#          True binary labels. If labels are not either {-1, 1} or {0, 1}, then pos_label should b
e explicitly given.
# y_score : array, shape = [n_samples]
#          Target scores, can either be probability estimates of the positive class, confidence va
lues, or
#          non-thresholded measure of decisions (as returned by "decision_function" on some
classifiers).
#
# Returns:
# fpr : array, shape = [>2]
#          Increasing false positive rates such that element i is the false positive rate of
predictions
#          with score >= thresholds[i].
#
# tpr : array, shape = [>2]
#          Increasing true positive rates such that element i is the true positive rate of
```

```
predictions
#           with score >= thresholds[i].
#
# thresholds : array, shape = [n_thresholds]
#           Decreasing thresholds on the decision function used to compute fpr and tpr.
thresholds[0] represents
#           no instances being predicted and is arbitrarily set to max(y_score) + 1.
#

train_tfidf_W2V_fpr, train_tfidf_W2V_tpr, tr_tfidf_W2V_thresholds = roc_curve(y_train,
y_train_tfidf_W2V_pred)
test_tfidf_W2V_fpr, test_tfidf_W2V_tpr, te_tfidf_W2V_thresholds = roc_curve(y_test,
y_test_tfidf_W2V_pred)

plt.plot(train_tfidf_W2V_fpr, train_tfidf_W2V_tpr, label="train AUC ="+str(auc(train_tfidf_W2V_fpr,
train_tfidf_W2V_tpr)))
plt.plot(test_tfidf_W2V_fpr, test_tfidf_W2V_tpr, label="test AUC ="+str(auc(test_tfidf_W2V_fpr, tes
t_tfidf_W2V_tpr)))
plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



In [167]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.confusion_matrix.html
print("="*100)
from sklearn.metrics import confusion_matrix

# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.confusion_matrix.html
# Compute confusion matrix to evaluate the accuracy of a classification
# Parameters:
#     y_true : array, shape = [n_samples]     Ground truth (correct) target values.
#     y_pred : array, shape = [n_samples]     Estimated targets as returned by a classifier.
#     labels : array, shape = [n_classes], optional
#              List of labels to index the matrix. This may be used to reorder or select a subset o
f labels.
#              If none is given, those that appear at least once in y_true or y_pred are used in so
rted order.
#     sample_weight : array-like of shape = [n_samples], optional      Sample weights.
#
# Returns:
#      C : array, shape = [n_classes, n_classes]         Confusion matrix
#

print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_tfidf_W2V_pred, tr_tfidf_W2V_thresholds,
train_tfidf_W2V_fpr, train_tfidf_W2V_fpr)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_tfidf_W2V_pred, te_tfidf_W2V_thresholds,
test_tfidf_W2V_fpr, test_tfidf_W2V_fpr)))
```

```
====================================================================================================

Train confusion matrix
```

```
the maximum value of tpr*(1-fpr) 0.24995726950388908 for threshold 0.851
[[ 1774  1821]
 [ 6214 12636]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24974728387470552 for threshold 0.857
[[1363 1279]
 [5572 8286]]
```

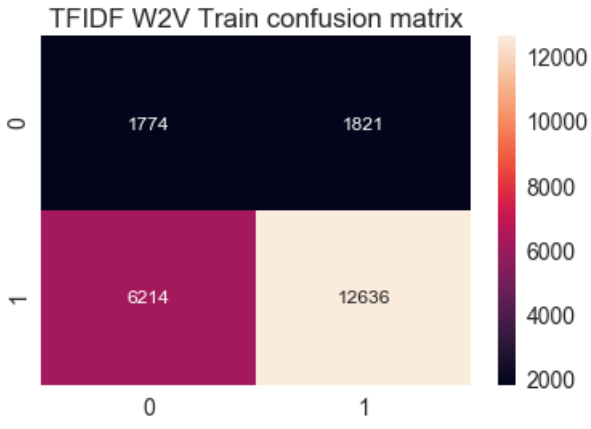
In [205]:

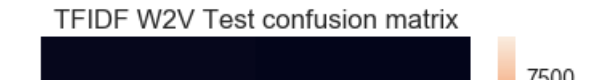
```
import seaborn as snTr
import seaborn as snTe
import pandas as pdH
import matplotlib.pyplot as plt

# https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
array=confusion_matrix(y_train, predict(y_train_tfidf_W2V_pred, tr_tfidf_W2V_thresholds,
train_tfidf_W2V_fpr, train_tfidf_W2V_fpr))
df_cm = pdH.DataFrame(array,range(2),range(2))

# https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
arrayTe=confusion_matrix(y_test, predict(y_test_tfidf_W2V_pred, te_tfidf_W2V_thresholds,
test_tfidf_W2V_fpr, test_tfidf_W2V_fpr))
df_cmTe = pdH.DataFrame(arrayTe,range(2),range(2))


# https://stackoverflow.com/questions/32723798/how-do-i-add-a-title-to-seaborn-heatmap
axTr = plt.axes()
axTr.set_title('TFIDF W2V Train confusion matrix')
snTr.set(font_scale=1.4)#for label size


# https://stackoverflow.com/questions/50947776/plot-two-seaborn-heatmap-graphs-side-by-side
fig, ax =plt.subplots(1,1)

axTe = plt.axes()
axTe.set_title('TFIDF W2V Test confusion matrix')
snTe.set(font_scale=1.4)#for label size

# https://seaborn.pydata.org/generated/seaborn.heatmap.html
snTr.heatmap(df_cm, annot=True,annot_kws={"size": 12},fmt="d",ax=axTr)# font size, format in digit


# https://seaborn.pydata.org/generated/seaborn.heatmap.html
snTe.heatmap(df_cmTe, annot=True,annot_kws={"size": 12},fmt="d",ax=axTe)# font size, format in
digit
```

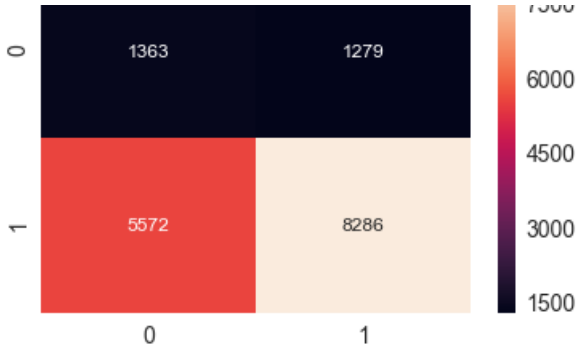
```
the maximum value of tpr*(1-fpr) 0.24995726950388908 for threshold 0.851
the maximum value of tpr*(1-fpr) 0.24974728387470552 for threshold 0.857
```

Out[205]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1edb471f9e8>
```







2.5 Feature selection with `SelectKBest`

In [0]:

```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your code

# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label

# https://scikit-learn.org/stable/modules/feature_selection.html#univariate-feature-selection
# 1.13.2. Univariate feature selection
# Univariate feature selection works by selecting the best features based on univariate
statistical tests.
# It can be seen as a preprocessing step to an estimator.
# Scikit-learn exposes feature selection routines as objects that implement the transform method:
#
# SelectKBest removes all but the  highest scoring features
#
# https://scikit-learn.org/stable/modules/generated/sklearn.feature_selection.SelectKBest.html
# Select features according to the k highest scores.

# what does SelectKBest do
# https://datascience.stackexchange.com/questions/10773/how-does-selectkbest-work
# The SelectKBest class just scores the features using a function (in this case f_classif but coul
d be others)
# and then "removes all but the k highest scoring features".
# >> So its kind of a wrapper, the important thing here is the function you use to score the featu
res.
# >> The k parameter is important if you use selector.fit_transform(), which will return a new arr
ay where the feature
# set has been reduced to the best 'k'.


# https://www.quora.com/How-do-I-properly-use-SelectKBest-GridSearchCV-and-cross-validation-in-the
-sklearn-package-together
# SelectKBest selects the top k features that have maximum relevance with the target variable.
# It takes two parameters as input arguments, "k" (obviously) and the score function to rate the r
elevance of every
# feature with the target variable. For example, for a regression problem, you can supply
# "feature_selection.f_regression" and for a classification problem, you can supply "feature_selec
tion.f_classif".
#
```

1. **[Task-2]**
   - Select top 2000 features from feature Set 2 using `SelectKBest` and then apply KNN on top of these features

```
from sklearn.datasets import load_digits
from sklearn.feature_selection import SelectKBest, chi2
X, y = load_digits(return_X_y=True)
X.shape
X_new = SelectKBest(chi2, k=20).fit_transform(X, y)
```

```
X_new.shape
========
output:
(1797, 64)
(1797, 20)
```

- Repeat the steps 2 and 3 on the data matrix after feature selection

2. **Conclusion**

- You need to summarize the results at the end of the notebook, summarize it in the table format. To print out a table please refer to this prettytable library link

---

In [168]:

```
from sklearn.feature_selection import SelectKBest
from sklearn.feature_selection import chi2
print(X_tr_tfidf.shape)

tfidf_Feature= SelectKBest(chi2,k=2000)
X_tr_tfidf_2K=tfidf_Feature.fit_transform(X_tr_tfidf,y_train)
X_cv_tfidf_2K=tfidf_Feature.fit_transform(X_cv_tfidf,y_cv)
X_te_tfidf_2K=tfidf_Feature.fit_transform(X_te_tfidf,y_test)
#print(X_tr_tfidf_2K.shape)
```

```
(22445, 22516)
```

In [169]:

```
print("Final Data matrix | tfidf")
print(X_tr_tfidf_2K.shape, y_train.shape)
print(X_cv_tfidf_2K.shape, y_cv.shape)
print(X_te_tfidf_2K.shape, y_test.shape)
print("="*100)
```

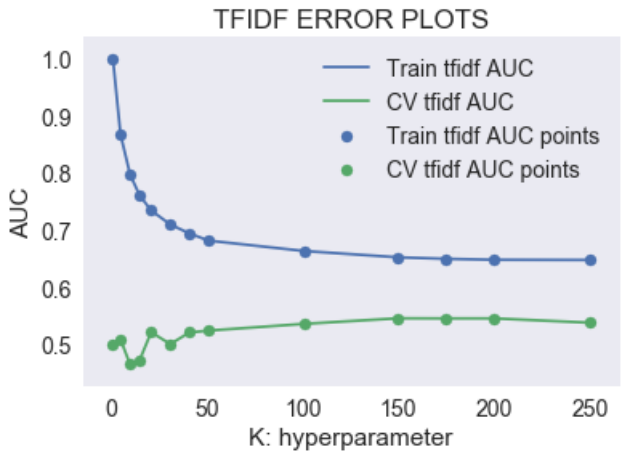
```
Final Data matrix | tfidf
(22445, 2000) (22445,)
(11055, 2000) (11055,)
(16500, 2000) (16500,)
====================================================================================================
```

In [170]:

```
#import matplotlib.pyplot as plt
#from sklearn.neighbors import KNeighborsClassifier
#from sklearn.metrics import roc_auc_score
#"""
#y_true : array, shape = [n_samples] or [n_samples, n_classes]
#True binary labels or binary label indicators.
#
#y_score : array, shape = [n_samples] or [n_samples, n_classes]
#Target scores, can either be probability estimates of the positive class, confidence values, or n
on-thresholded measure of
#decisions (as returned by "decision_function" on some classifiers).
#For binary y_true, y_score is supposed to be the score of the class with greater label.
#
#"""
#
#train_tfidf_SKB_auc = []
#cv_tfidf_SKB_auc = []
#K = [1, 5, 10, 15, 21, 31, 41, 51, 101, 150, 175, 200, 250]
#for i in tqdm(K):
#    neigh = KNeighborsClassifier(n_neighbors=i,algorithm='brute')
#    neigh.fit(X_tr_tfidf_2K, y_train)
#
#    #print(X_cv_tfidf.shape)
#
#    y_train_tfidf_2K_pred = batch_predict(neigh, X_tr_tfidf_2K)
#    y_cv_tfidf_2K_pred = batch_predict(neigh, X_cv_tfidf_2K)
```

```
#     # this will predict the probablity for data x_tr ot cv
#
#     # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the pos
itive class
#     # not the predicted outputs
#
#     # https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_auc_score.html#sklearn.metrics.roc_auc_score

#     #
#     train_tfidf_SKB_auc.append(roc_auc_score(y_train,y_train_tfidf_2K_pred))
#     cv_tfidf_SKB_auc.append(roc_auc_score(y_cv, y_cv_tfidf_2K_pred))
#
####################################################################
## stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-s
ave-and-load-variables-in-python/
#
#import pickle
#with open('train_tfidf_SKB_auc', 'wb') as f:
#     pickle.dump(train_tfidf_SKB_auc, f)
#
#with open('cv_tfidf_SKB_auc', 'wb') as f:
#     pickle.dump(cv_tfidf_SKB_auc, f)
####################################################################
#plt.plot(K, train_tfidf_SKB_auc, label='Train tfidf AUC')
#plt.plot(K, cv_tfidf_SKB_auc, label='CV tfidf AUC')
#
#plt.scatter(K, train_tfidf_SKB_auc, label='Train tfidf AUC points')
#plt.scatter(K, cv_tfidf_SKB_auc, label='CV tfidf AUC points')
#
#plt.legend()
#plt.xlabel("K: hyperparameter")
#plt.ylabel("AUC")
#plt.title("TFIDF ERROR PLOTS")
#plt.grid()
#plt.show()
```

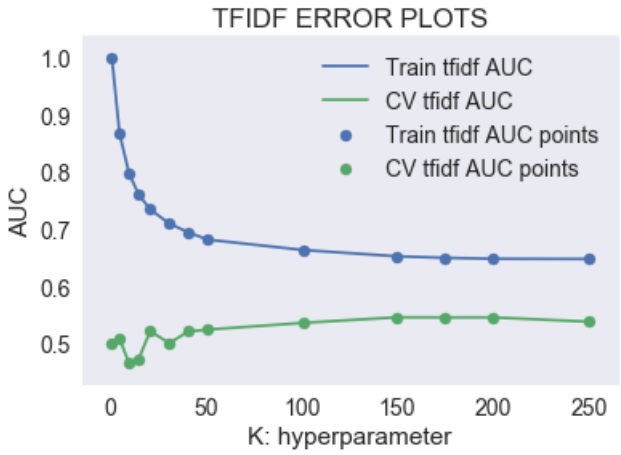
```
100%|██████████████████████████████████████████████████████████████████████████████████████████| 13/13
[11:34<00:00, 54.70s/it]
```



In [173]:

```
import matplotlib.pyplot as plt
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-sa
ve-and-load-variables-in-python/
# make sure you have the glove_vectors file
with open('train_tfidf_SKB_auc', 'rb') as f:
    train_tfidf_SKB_auc = pickle.load(f)
with open('cv_tfidf_SKB_auc', 'rb') as f:
    cv_tfidf_SKB_auc = pickle.load(f)

plt.plot(K, train_tfidf_SKB_auc, label='Train tfidf AUC')
plt.plot(K, cv_tfidf_SKB_auc, label='CV tfidf AUC')

plt.scatter(K, train_tfidf_SKB_auc, label='Train tfidf AUC points')
plt.scatter(K, cv_tfidf_SKB_auc, label='CV tfidf AUC points')
```

```
plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("TFIDF ERROR PLOTS")
plt.grid()
plt.show()
```



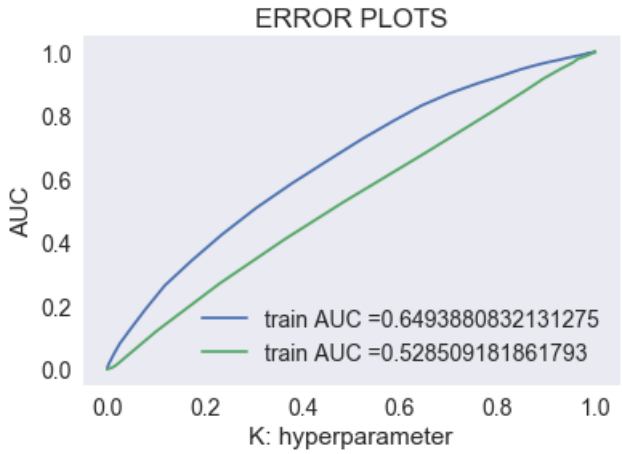
In [171]:

```
best_tfidf_k = 175
# from the error plot we choose K such that, we will have maximum AUC on cv data and gap between t
he train and cv is less
```

In [206]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


neigh = KNeighborsClassifier(n_neighbors=best_tfidf_k,algorithm='brute')
neigh.fit(X_tr_tfidf_2K, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_tfidf_2K_pred = batch_predict(neigh, X_tr_tfidf_2K)
y_test_tfidf_2K_pred = batch_predict(neigh, X_te_tfidf_2K)

# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
# Compute Receiver operating characteristic (ROC)
# y_true : array, shape = [n_samples]
#          True binary labels. If labels are not either {-1, 1} or {0, 1}, then pos_label should b
e explicitly given.
# y_score : array, shape = [n_samples]
#          Target scores, can either be probability estimates of the positive class, confidence va
lues, or
#          non-thresholded measure of decisions (as returned by "decision_function" on some
classifiers).
#
# Returns:
# fpr : array, shape = [>2]
#          Increasing false positive rates such that element i is the false positive rate of
predictions
#          with score >= thresholds[i].
#
# tpr : array, shape = [>2]
#          Increasing true positive rates such that element i is the true positive rate of
predictions
#          with score >= thresholds[i].
#
# thresholds : array, shape = [n_thresholds]
#          Decreasing thresholds on the decision function used to compute fpr and tpr.
thresholds[0] represents
#          no instances being predicted and is arbitrarily set to max(y_score) + 1.
#
```

```
"

train_tfidf_2K_fpr, train_tfidf_2K_tpr, tr_tfidf_2K_thresholds = roc_curve(y_train,
y_train_tfidf_2K_pred)
test_tfidf_2K_fpr, test_tfidf_2K_tpr, te_tfidf_2K_thresholds = roc_curve(y_test,
y_test_tfidf_2K_pred)

plt.plot(train_tfidf_2K_fpr, train_tfidf_2K_tpr, label="train AUC ="+str(auc(train_tfidf_2K_fpr, tr
ain_tfidf_2K_tpr)))
plt.plot(test_tfidf_2K_fpr, test_tfidf_2K_tpr, label="train AUC ="+str(auc(test_tfidf_2K_fpr,
test_tfidf_2K_tpr)))
plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



In [207]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.confusion_matrix.html
print("="*100)
from sklearn.metrics import confusion_matrix

# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.confusion_matrix.html
# Compute confusion matrix to evaluate the accuracy of a classification
# Parameters:
#     y_true : array, shape = [n_samples]     Ground truth (correct) target values.
#     y_pred : array, shape = [n_samples]     Estimated targets as returned by a classifier.
#     labels : array, shape = [n_classes], optional
#              List of labels to index the matrix. This may be used to reorder or select a subset o
f labels.
#              If none is given, those that appear at least once in y_true or y_pred are used in so
rted order.
#     sample_weight : array-like of shape = [n_samples], optional      Sample weights.
#
# Returns:
#      C : array, shape = [n_classes, n_classes]         Confusion matrix
#

print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_tfidf_2K_pred, tr_tfidf_2K_thresholds,
train_tfidf_2K_fpr, train_tfidf_2K_fpr)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_tfidf_2K_pred, te_tfidf_2K_thresholds,
test_tfidf_2K_fpr, test_tfidf_2K_fpr)))
```

```
====================================================================================================

Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24952319420613933 for threshold 0.88
[[ 1719  1876]
 [ 5184 13666]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24973510651039144 for threshold 0.886
[[1364 1278]
 [6567 7291]]
```

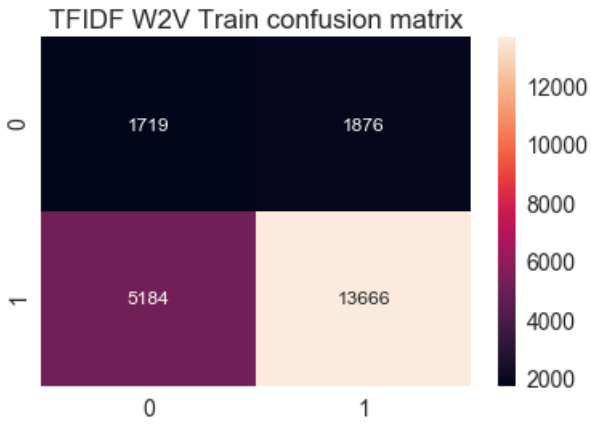
In [208]:

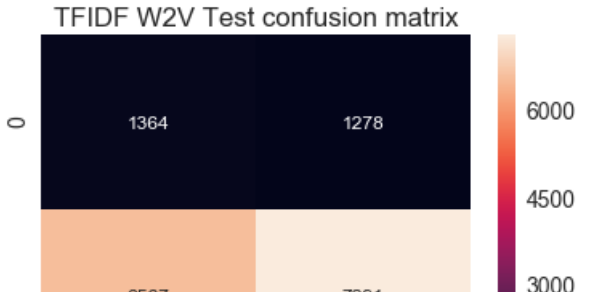
```
import seaborn as snTr
import seaborn as snTe
import pandas as pdH
import matplotlib.pyplot as plt

# https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
array=confusion_matrix(y_train, predict(y_train_tfidf_2K_pred, tr_tfidf_2K_thresholds,
train_tfidf_2K_fpr, train_tfidf_2K_fpr))
df_cm = pdH.DataFrame(array,range(2),range(2))

# https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
arrayTe=confusion_matrix(y_test, predict(y_test_tfidf_2K_pred, te_tfidf_2K_thresholds,
test_tfidf_2K_fpr, test_tfidf_2K_fpr))
df_cmTe = pdH.DataFrame(arrayTe,range(2),range(2))


# https://stackoverflow.com/questions/32723798/how-do-i-add-a-title-to-seaborn-heatmap
axTr = plt.axes()
axTr.set_title('TFIDF W2V Train confusion matrix')
snTr.set(font_scale=1.4)#for label size


# https://stackoverflow.com/questions/50947776/plot-two-seaborn-heatmap-graphs-side-by-side
fig, ax =plt.subplots(1,1)

axTe = plt.axes()
axTe.set_title('TFIDF W2V Test confusion matrix')
snTe.set(font_scale=1.4)#for label size

# https://seaborn.pydata.org/generated/seaborn.heatmap.html
snTr.heatmap(df_cm, annot=True,annot_kws={"size": 12},fmt="d",ax=axTr)# font size, format in digit


# https://seaborn.pydata.org/generated/seaborn.heatmap.html
snTe.heatmap(df_cmTe, annot=True,annot_kws={"size": 12},fmt="d",ax=axTe)# font size, format in
digit
```

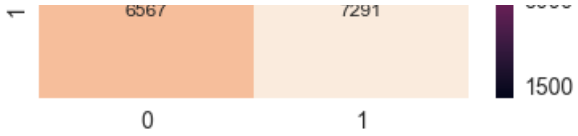
```
the maximum value of tpr*(1-fpr) 0.24952319420613933 for threshold 0.88
the maximum value of tpr*(1-fpr) 0.24973510651039144 for threshold 0.886
```

Out[208]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1edb4843b00>
```







3. Conclusions

Please compare all your models using Prettytable library

Apology for not submitting in first attempt, actuallly i added the conclusion, but

since the size was biz and i could not able to convert into pdf, i made the copy and somehow this section was missed

probably i didn't save the notepad before copying the file

In [210]:

```
# Please compare all your models using Prettytable library
from prettytable import PrettyTable

x = PrettyTable()

x.field_names = ["Vectorizer", "Model", "Hyper parameter", "AUC"]

x.add_row(["BOW", "Brute", 200, 0.607 ])
x.add_row(["TFIDF", "Brute", 200, 0.616 ])
x.add_row(["AvgW2V", "Brute", 175 , 0.577])
x.add_row(["TFIDF W2V", "Brute", 175, 0.573])


print(x)
```

```
+------------+-------+-----------------+-------+
| Vectorizer | Model | Hyper parameter |  AUC  |
+------------+-------+-----------------+-------+
|    BOW     | Brute |       200       | 0.607 |
|   TFIDF    | Brute |       200       | 0.616 |
|   AvgW2V   | Brute |       175       | 0.577 |
| TFIDF W2V  | Brute |       175       | 0.573 |
+------------+-------+-----------------+-------+
```

Conclusion

Step followed

- Preprocessing of Project_subject_categories and Project_subject_subcategories
- Preprocessing of Project_essay and Project_title
- Vectorization(one hot encoding) for clean_category, clean_subcategory, teacher_prefix
- Vectorization(one hot encoding) for BOW(project_essay and project_title) for TFIDF(project_essay and project _title)
- Vectorization of Average Word2Vec for Project_essay
- Vectorization of TFIDF weighted W2V for Project_essay
- Vectorization of Average Word2Vec for Project_title
- Vectorization of TFIDF weighted W2V for Project_title
- Vectorizing Numeric features (Standardization of Price column)
- Splitting Data into Train (further split into Train and Cross validation) and Test.
- Making datamodel ready
  - text
  - encoding school_state and convert into Train,CV and Test vector
  - encoding clean_category and convert into Train,CV and Test vector
  - encoding clean_subcategory and convert into Train,CV and Test vector

    - encoding project_grade_category and convert into Train,CV and Test vector
    - encoding teacher_prefix and convert into Train,CV and Test vector
    - encoding project_title(BOW) and convert into Train,CV and Test vector
    - encoding project_essay(BOW) and convert into Train,CV and Test vector
    - encoding project_resource_summary and convert into Train,CV and Test vector
    - numeric
    - encoding quantity and convert into Train,CV and Test vector
    - encoding teacher_number_of_previously_posted_projects and convert into Train,CV and Test vector
    - encoding price and convert into Train,CV and Test vector
- Merging all the above features for SET 1 Horizontally merging(with hstack) all categorical, numerical features + project_title(BOW) + preprocessed_essay (BOW)
- Merging all the above features for SET 2
    - TFIDF vectorization for project_essay
    - TFIDF vectorization for project_title Horizontally merging(with hstack) all categorical, numerical features + project_title(TFIDF)+ preprocessed_essay (TFIDF)
- Merging all the above features for SET 3
    - Avg W2V vectorization for project_essay
    - Avg W2V vectorization for project_title Horizontally merging(with hstack) all categorical, numerical features + project_title(Avg W2V)+ preprocessed_essay (Avg W2V)
- Merging all the above features for SET 4
    - TFIDF W2V vectorization for project_essay
    - TFIDF W2V vectorization for project_title Horizontally merging(with hstack) all categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_essay (TFIDF W2V)
- Hyper paramter tuning to find best K define batch_predict() function, which will takes Classifier and data as input 1 Draw a graph for different value of K, between Train and CV of BOW data (SET 1) 2 Choose the Best K, by seeing from above created graph 3 Draw AUC for Train and Test data 4 Create Confusion matrix, in heatmap.
    - Do the above four steps for TFIDF
    - Do the above four steps for avgW2V
    - Do the above four steps for TFIDF W2V
- with SelectKBest function, taking chi2 as function classifier and remove all but top 2000, K highest scoring features, for TFIDF data (SET 2)
    - Do all the four steps mentioned above.

P.S. After 1st subbmission, below changes i did.

- try to learn and implement pickle data, so it won;t waste my time in future assignment, just to rerun the cells from begining
- added tqdm in for loop, just to see the progress of execution.